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Modelling Air Passenger Judgements and Choices Using Conjoint Methodology

5/27

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Modelling Air Passenger Judgements and Choices Using Conjoint Methodology

Abstract

In this paper we report our findings which pertain to the application of conjoint analysis to assess air passenger judgements about air travel preferences and their choice of carrier. The conjoint application involves posing various trade-offs to travellers in order to assess preferences. Our focus pertains to the optimal number of attributes to include in the experiment. We test passenger trade-off structures with two, three, four, five and six factors and discover that the optimal number is five factors. Conjoint experiments comprised of five attributes outperforms other combinations in terms of incurring the least variance and highest goodness-of-fit indices.

Modelling Air Passenger Judgements and Choices Using Conjoint Methodology

INTRODUCTION

The effectiveness of multiattribute methods for analyzing consumer preferences depends ultimately on their ability not only to represent preferences for the product or choice situation of interest, but also how those preferences are related to choices in real-world situations. Conjoint analysis represents a class of multiattribute modelling approaches employed to uncover underlying preference structures and, furthermore, maps preference structures to actual choices.

The primary purpose of this study is to assess the optimal number of attributes to include in a conjoint experiment involving the decision of which air carrier to select for a pleasure trip. Researchers have discovered that the reliability and validity of conjoint results are critically related to the number of stimuli (attributes) included in the experiment (Green and Srinivasan, 1978). Too many attributes increases confusion while too few renders the choice situation highly unreal to participants. We employ measures of model aptness and predictive efficiency to assess the optimal number of factors. A second purpose is to determine the importance of carrier country of origin in the airline choice decision. Academic researchers have reported evidence that in many product categories the country of origin or manufacturing of the product affected consumer purchase decisions and quality assessments. We wish to test the country of origin effect in the present study.

The remaining sections of the paper address the literature focusing on conjoint analysis, the experiment conducted to empirically assess the optimal number of attributes, and the implications for air passenger choice modelling.

LITERATURE REVIEW

Conjoint Analysis

For the past two decades conjoint analysis has increased in popularity as a method to portray consumers' decisions realistically as trade-offs among multiattribute products or services. In fact, one source reports that usage rates for the technique have increased ten-fold during the decade of the 1980s (Wittink and Cattin, 1989; Wittink, Vrienz, and Burhenne, 1992).

Conjoint is closely associated with traditional experimentation. Subjects (respondents) are presented a set of product/service attributes with multiple levels associated with each attribute and asked to rank or rate their preferences for alternative attribute combinations. For example, a traveller is likely to use ticket price, availability of frequent flyer program, number of stops enroute, and brand (air carrier), among other factors, in arriving at a decision as to which flight to purchase. Conjoint analysis would involve constructing various sets of ticket prices, stops, mileage programs, and air carriers as stimuli for travellers to judge in either a ranking or rating exercise. Conjoint analysis is best suited for understanding travellers' reactions to and evaluations of predetermined flight attribute combinations that represent potential choice situations they may confront in choosing an air carrier.

Widely used in marketing research, the technique represents a consumer side approach to evaluating product attributes, individual characteristics, and situational factors on consumer preferences and choices. Conjoint analysis has been found to be both practical and unbiased (Green and Srinivasan, 1978; Carmone, Green, and Jain, 1978).

RESEARCH DESIGN

Sample

A total of 400 travellers participated in the conjoint experiment (100 travellers for each of the four attribute combinations). Respondents were interviewed on-site at a large, international airport in Canada. A non-probability quote sample was employed. Travellers were interviewed at each hour of the day, day of the week, and at various air carrier gates prior to flight departure. Furthermore, interviewers were instructed to select participants based on gender (male = 65%, female = 35%), and age (less than 20 = 12%, between 20 and 40 = 35%, between 40 and 65 = 40%, and over 65 = 8%). Samples employed in the study were representative of the proportions of air travellers commonly departing from the airport. Thus, although non-probabilistic in design, it is felt the sample adequately represents the population of air travellers.

Conjoint Exercise

The study was designed around a travel scenario which was presented to respondent travellers prior to a domestic flight. The scenario described a *pleasure* trip between two points in North America. The hypothetical trip presented in the scenario was designed with almost identical features to one listed in a major travel reservation system. We sought to develop a scenario which was as realistic as possible in order to improve respondant participation and accuracy of judgements and choices.

Travellers were asked to evaluate a set of flight attributes and to rate each set according to their *most preferred* set for the hypothetical flight posed in the scenario. The task involved air traveller evaluations of flight attributes, a product class frequently studied in conjoint research (cf. Green and Wind, 1975; Bruning and Hu, 1984; Bruning, 1995; Bruning 1996; Bruning, Prentice, and Bellamy, 1996). Since the purpose of the study was to determine the optimal number of flight attributes to include in a conjoint experiment, the scenario was tested with five different samples of air travellers using two, three, four, five, and six attribute combinations for different respondent sub-samples. Flight attributes were selected based on findings of previous research focusing on flight attribute preferences (Bruning 1995; Bruning and Hu 1984; Cook and bla bla ; and Thorton). In selecting the attributes, we identified those reported in previous literature and pre-tested a sample of 50 air travellers as to the most preferred to least preferred attributes in order to confirm the orderings prior to administration in the experiment. The attribute combinations are presented in Table 1.

Enter Table 1 About Here

In the conjoint exercise respondents were presented with two to six attributes to evaluate. In all cases, two attributes were presented to all respondents; namely, ticket price and country of carrier carrier. With respect to the identification of carriers employed in the scenario, we have alternated two separate forms of identification throughout the experiment. One-half of all respondents were presented scenarios identifying carriers as either a Canadian carrier, a U.S. carrier, or a Mexican carrier. The other one-half of respondents were presented with specific carrier names, e.g., Air Canada, Northwest Airlines, and Air Mexico. The difference is not trivial, however. The literature in country-of-origin research suggests that the national identification of producers/suppliers will impact the choices and judgements consumers make. Furthermore, since carrier country-of-origin is also a particular brand (with country and carrier-specific stereotypes), it is suspected that the scenario with country only identified would respond differently compared to the scenario presenting specific carriers as alternatives. Thus, to account for the possible bias due to country-of-origin or carrier name, we have structed the sample to test for this likelihood.

Finally, we sought to control the effect on ratings and choices of attributes not included in the study. Respondents were instructed that profiled flight attributes were based on actual levels occuring on actual flights. They were also instructed to assume that all other aspects of the flight were similar for all competing air carriers. Fixing the levels of unobserved attributes increases confidence that choices and differences in ratings are due to differences on the manipulated attributes (Johnson 1987; Johnson and Levin 1985).

Procedure

The procedure employed in administering the conjoint experiment was standardized for all interviewers. One and on-half hours prior to a flight's departure interviewers would approach travellers located in air carrier gate areas. Interviewers would introduce themselves, explain the project, and asked travellers if they would participate in the study. If allowed to continue, interviewers would check for citizenship as we were interested in interviewing Canadian citizens only. Once having screened for citizenship, interviewers would present respondents with the hypothetical travel scenario. They would describe each flight attribute (two, three, four, five, or six attributes depending on the sample) and explain the rating form (response options ranged from 1 = Very Low Preference to 9 = Very High Preference). Once all attributes were explained, the scenario was described in full, the choice exercise was explained, and respondents were asked to imagine their most-preferred combination of flight attributes and levels, interviewers then presented respondents with a series of flash cards. The cards depicted various flight attribute combinations and were presented one at a time. Respondents were asked to make a rating on the coding form (from a value of 1 to 9) based on a comparison of each combination to the respondent's most-preferred combination. A fractional factorial design was used to reduce the conjoint exercise to manageable proportions by accounting for main effects and not interactions (Cochran and Cox 1957). Thus, each respondent provided from five (case with only two attributes) to eighteen (case with six flight attributes) ratings. These ratings were used in determining aggregate part-worth estimates for each attribute and attribute level in the conjoint analysis. In the analysis, ratings represented the dependent variable and the effect coded dummy variables served as independent variables in deriving part-worth estimates from OLS regression analysis.

The null hypothesis of the study posited that the performance of the regression equations representing each of the five samples (each sample presented with a certain number of flight attributes to evaluate), as well as the samples based on country identification versus carrier identification, were the same, (i.e., that the number of attributes included in the conjoint exercise had no significant effect on predictive accuracy). Thus, the input into the statistical tests were measures of goodness-of-fit (adjusted r-squrare) and variance (regression standard error and mean square error). The alternative hypothesis (that the number of attributes included in the model would affect predictive accuracy) was accepted if, indeed, the tests indicated that the null hypothesis was rejected.

RESULTS

Attribute Importance

The conjoint results for each of the five groups are reported in Tables 2 through 6. In Table 2, summary statistics relating to the two flight attributes (price and carrier) are presented for each carrier identification method. The data indicate that respondents placed greater relative importance on the country of carrier factor regardless of the method of carrier identification.

Table 3 presents the assessment for a second sample of 100 respondents who compared three flight attributes (i.e., price, number of stops, and country of carrier). The table reports that, as in the two-attribute case, country of carrier was the dominant flight attribute accounting for the highest importance value regardless of method of carrier identification. Price was a distant second attribute in terms of attribute importance for the sample of travellers.

A third sample of 100 respondents indicated a preference pattern similar to the first two reported in the study. Table 4 reports the conjoint results. After including in-flight services as a distinct attribute in the assessment, country of carrier was rated as most important for both country-only and carrier identified sub-samples. Price was second-most important followed by the number of stops and in-flight services. Actually, in-flight services were seen as quite insignificant which corraborates earlier research by Bruning (1995, 1996) and Bruning, Prentice, and Bellamy (1996).

The fourth sample of 100 respondents evaluated five flight attributes; namely, price, number of stops, in-flight services, country of carrier/carrier name, and a fifth factor unique to this sample, on-time performance. Table 5 reports that country of carrier/carrier identification attribute dominated all other factors. Unlike importance scores reported in Tables 2, 3, and 4, with the inclusion of a fifth factor, on-time performance, price has declined in importance and is eclipsed by the added attribute. In-flight services remains a relatively insignificant factor in comparison to all others, although in the five-attribute sample the number of stops has declined to fourth place.

In summary, the conjoint part-worth estimates and corresponding importance values are relatively stable as the number of flight attributes was altered in the travel scenario. The stability is represented graphically for each factor across the five different samples in Figures 3 through 6. The pattern for the price attribute, depicted in Figure 3, declines steadily in importance as additional attributes are added to the scenario. The carrier attribute pattern, represented in Figure 4, always ranks as most important, except the five-attribute with carrier name scenario, and represents a fairly constant trend across the five samples. Figures 5 and 6 depict the number of stops and on-time performance attributes across the several samples. The two attributes are typically either third or fourth ranked in terms of importance, while in-flight services, Figure 6, always ranks least important among the five samples. The final attribute included in the model, on-time performance, enters in the final stage and moves to the second position after country of carrier. In conclusion, the analyses indicates a rather stable pattern of part worth coefficients and relative importance scores across the five samples.

Predictive Efficiency

Parameter estimation equations for all samples were statistically significant at the $p<.01$ level based on the calculated F-statistic. OLS regression was used as the estimation approach and preliminary diagnostics indicate that none of the fundamental assumptions were seriously violated. A fundamental tenet of conjoint analysis is that attributes are independent of one another. An analysis of interaction terms in the regression equations indicated that, indeed, first-level interaction among flight attribute levels is statistically insignificant.

Goodness-of-fit. One of the major indicators of explanatory power in regression analysis is the R-square statistic adjusted for degrees of freedom. In essence, the adjusted R-square statistic indicates the degree to which the explanatory variables model variation in the dependent or predictor variable. In this analysis, the index represents one dimension of the explanatory ability of the set of flight attributes in estimating the importance of various trip attribute combinations.

Figure 1 summarizes the trend for adjusted R-square statistics in terms of country identified and carrier identified models. As shown in the figure, adjusted R-square measures range from a high of .585 to a low of .191. In general, we can say that the explanatory factors perform reasonably well in modelling the importance ratings across the five samples. Furthermore, Figure 1 dramatizes the variation in adjusted R-square measures as the number of factors in the scenario increases. While the estimates for the country-identified equation tend to incur slightly higher measures compared to the estimates from the carrier-identified model, the difference is trivial. A difference in ranks test concluded no significant difference between the two trends at the $p<.05$ level or below. Furthermore, an assessment of the mean absolute difference indicated an insignificant difference in adjusted R-square measures across the five samples. With respect to the goodness-of-fit index, the results of our analysis indicate that predictive ability is, in general, not significantly affected by the number of attributes presented in the scenario when the number of attributes is between two and five. The results, however, do not generalize to attribute combinations greater than five.

Variance. Another indice useful in assessing the predictive ability of the conjoint regression equations is the mean square error which measures the extent to which error exists in the estimated parameters. In Figure 2, mean square errors for the four samples are presented for both the country and carrier-based conjoint presentations. As presented in the figure, mean square errors indicate a slight trend downward as the number of factors increased from two to five. For the country-based presentations, mean square errors initially drop and then begin a slight rise from two to five attributes. The carrier-based presentations, on the other hand, indicate a more random pattern, alternating between increases and decreases. There appears to be a convergence between the country and carrier-based conjoint presentations for the five-attribute samples.

A second measure of predictive ability is constructed by using the split-sample technique whereby the first half of the sample is used to calibrate the regression model parameters used to estimate the dependent variable in the second half of the data set. Figure 7 presents the trend in MSE to MSPE (mean square prediction error) for the four samples. As indcated in the figure, MSPE declines steadily over the first three samples, and begins rising afterwards. MSE, on the other hand, is relatively stable over the four samples. Thus, we find support for including four to five factors in the conjoint exercise based on predictive efficiency.

Summary

Our data indicate that it is appropriate to include a sizeable number of attributes in the conjoint experiment rather than opting for parsimony in the extreme. Two or three attributes with three levels each result in greater variance and less predictive efficiency relative to four or five attributes. Furthermore, the attributes selected for this study appear to account for a healthy proportion of the variance of the conjoint ratings. In summary, our findings are as follows:

1. Country of origin of the carrier is one of the more important factors in the airline choice decision when several national carriers are competing. Individuals will tend to support the carrier from their own country before one from another country.

2. Generally, differences are noticeable using country versus carrier as the product cue; however, these differences are not pronounced in the case of air carriers. The finding implies that country of carrier may summarize the brand-based information in cases where nationality is not evident in the carrier's name.

3. Considering all performance measures, between four and five factors appear optimal in conjoint experiments dealing with airline choice behavior.Parameter estimation equations for all samples were statistically significant at the $p<.01$ level based on the calculated F-statistic. OLS regression was used as the estimation approach and preliminary diagnostics indicate that none of the fundamental assumptions were seriously violated. An important tenet of conjoint analysis is that attributes are independent of one another. An analysis of interaction terms in the regression equations indicated that, indeed, first-level interactions among flight attribute levels is statistically insignificant.

Table 1

Conjoint Experimental Attributes and Attribute Levels

Attribute	Attribute Level		
Price	Low = $560	Medium = $685	High = $779
In-Flight Services	Low = Poor selection of magazines; no newspapers; no meals; too-few attendants for satisfactory service; poor music quality; noisy aircraft.		
	Medium = At least one interesting magazine; no newspaper; a cold sandwich and dessert; satisfactory speed of service; several reasonable radio stations; aircraft not too noisy; attendant staff congenial.		
	High = Good selection of magazines; current newspaper; a hot meal; quick and effective service; music and movie; very quiet aircraft; and excellent staff.		
Number of Stops Before Destination	Two Stops	One Stop	Non-Stop
On-Time Performance	70% on time	85% on time	95% on time
Country of Carrier/ Name of Carrier	Mexico Air Mexico	United States Northwest Air	Canada Air Canada

Table 2
Two-Factor Sample Part Worth Utilities and Importance Values

I. *Country of Carrier Identified*

Attribute	Part Worth Utilities	Attribute Range	Percent Importance
PRICE		4.305	49.5%
$560	3.144		
$684	1.161		
$779	-4.305		
COUNTRY		4.401	50.5%
Canada	2.828		
United States	1.573		
Mexico	-4.401		

Adj. R-square = .335
S.E. of Reg. = 1.914
MSE = 3.665

II. *Name of Carrier Identified*

Attribute	Part Worth Utilities	Attribute Range	Percent Importance
PRICE		3.690	45.0%
$560	2.638		
$684	1.052		
$770	-3.690		
CARRIER		4.570	55.0%
Air Canada	2.718		
Northwest	1.852		
Air Mexico	-4.570		

Adj. R-square = .434
S.E. of Reg. = 1.781
MSE = 3.171

Table 3
Three-Factor Sample Part Worth Utilities and Importance Values

I. *Country of Carrier Identified*

Attribute	**Part Worth Utilities**	**Attribute Range**	**Percent Importance**
PRICE		2.926	32%
$560	2.033		
$684	.893		
$779	-2.926		
COUNTRY		5.447	60%
Canada	2.907		
United States	2.540		
Mexico	-5.447		
NUMBER OF STOPS		.687	8%
Two-Stops	-.687		
One-Stop	.387		
Non-Stop	.300		

Adj. R-square = .585
S.E. of Reg. = 1.299
MSE = 1.687

II. *Name of Carrier Identified*

Attribute	**Part Worth Utilities**	**Attribute Range**	**Percent Importance**
PRICE		3.207	39%
$560	2.187		
$684	1.020		
$779	-3.207		
COUNTRY		4.367	54%
Air Mexico	-4.367		
Northwest	1.847		
Air Canada	2.520		
NSTOPS		1.134	7%
Two-Stop	-.567		
One-Stop	.367		
Non-Stop	.200		

Adj. R-square = .405
S.E. of Reg. = 1.682
MSE = 2.828

Table 4
Four-Factor Sample Part Worth Utilities and Importance Values
I. *Country of Carrier Identified*

Attribute	Part Worth Utilities	Attribute Range	Percent Importance
PRICE		2.124	36%
$560	1.531		
$684	.593		
$779	-2.124		
COUNTRY		2.552	43%
Canada	1.420		
United States	1.132		
Mexico	- 2.552		
NUMBER OF STOPS		..998	17%
Two-Stops	- .998		
One-Stop	.427		
Non-Stop	.571		
INFLIGHT SERVICES		.235	4%
Low	-.235		
Medium	-.191		
High	-.044		

Adj. R-square = .336
S.E. of Reg. = 1.214
MSE = 1.473

II. *Name of Carrier Identified*

Attribute	Part Worth Utilities	Attribute Range	Percent Importance
PRICE		2.260	36%
$560	1.514		
$684	.746		
$779	-2.260		
COUNTRY		2.340	54%
Air Mexico	-2.340		
Northwest	1.136		
Air Canada	1.204		
NSTOPS		1.421	22%
Two-Stop	-1.421		
One-Stop	.540		
Non-Stop	.881		
INFLIGHT SERVICES		.326	5%
Low	-.326		
Medium	-.188		
High	-.138		

Adj. R-square = .191
S.E. of Reg. = 1.796
MSE = 3.227

Table 5
Five-Factor Sample Part Worth Utilities and Importance Values
I. *Country of Carrier Identified*

Attribute	Part Worth Utilities	Attribute Range	Percent Importance
PRICE		1.862	22%
$560	1.330		
$684	.532		
$779	-1.862		
COUNTRY		4.781	58%
Canada	2.885		
United States	1.896		
Mexico	-4.781		
NUMBER OF STOPS		.098	1%
Two-Stops	-.098		
One-Stop	-.168		
Non-Stop	.070		
INFLIGHT SERVICES		.105	1%
Low	-.105		
Medium	.130		
High	-.025		
ON TIME PERFORMANCE		1.500	18%
Low	-1.500		
Medium	.535		
High	.965		

Adj. R-square = .401
S.E. of Reg. = 1.458
MSE = 2.126

Table 5 cont.
Five-Factor Sample Part Worth Utilities and Importance Values
II. *Name of Carrier Identified*

Attribute	Part Worth Utilities	Attribute Range	Percent Importance
PRICE		1.083	12%
$560	.973		
$684	.110		
$779	-1.083		
COUNTRY		5.718	62%
Air Mexico	-5.718		
Northwest	2.795		
Air Canada	2.923		
NSTOPS		.716	8%
Two-Stop	-.716		
One-Stop	.273		
Non-Stop	.443		
INFLIGHT SERVICES		.423	4%
Low	-.423		
Medium	.310		
High	.113		
ON TIME PERFORMANCE		1.271	14%
Low	-1.271		
Medium	.363		
High	.908		

Adj. R-square = .516
S.E. of Reg. = 1.283
MSE = 1.647

Figure 1

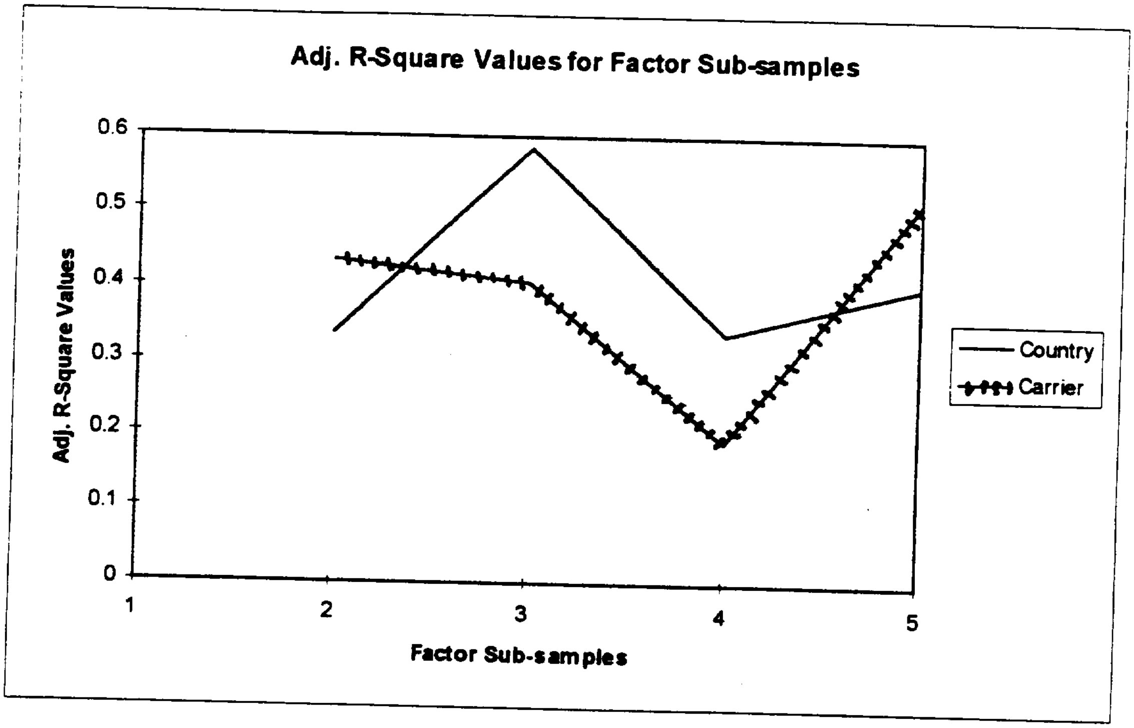

Adj. R-Square Values for Factor Sub-samples
0.6
0.5
0.4
0.3
0.2
0.1
0
1
2
3
4
5
Adj. R-Square Values
Factor Sub-samples
Country
Carrier

Figure 2

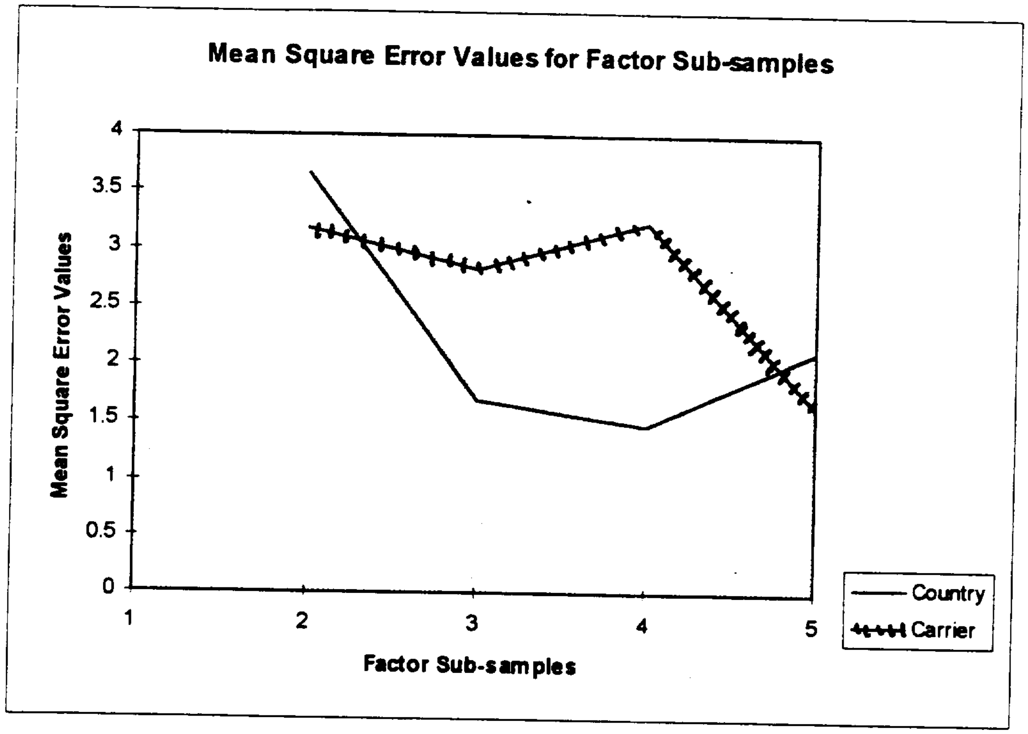

Mean Square Error Values for Factor Sub-samples
Mean Square Error Values
4
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
4
5
Factor Sub-samples
Country
Carrier

Figure 3

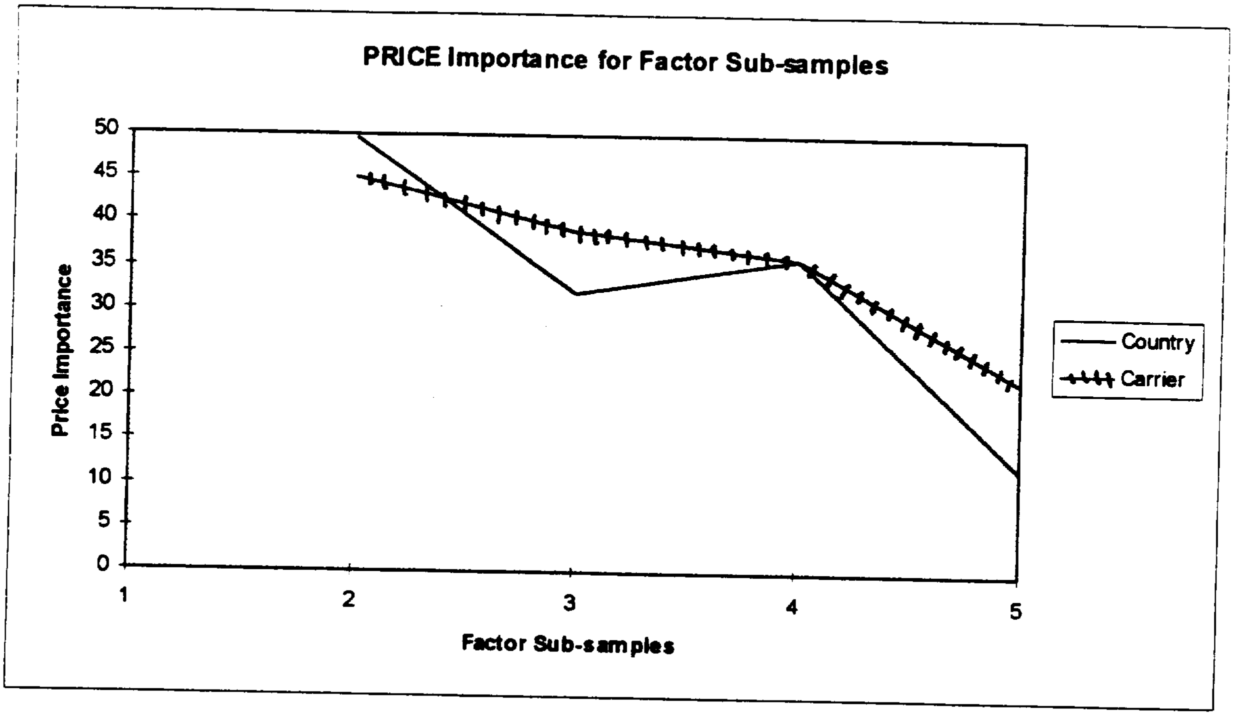
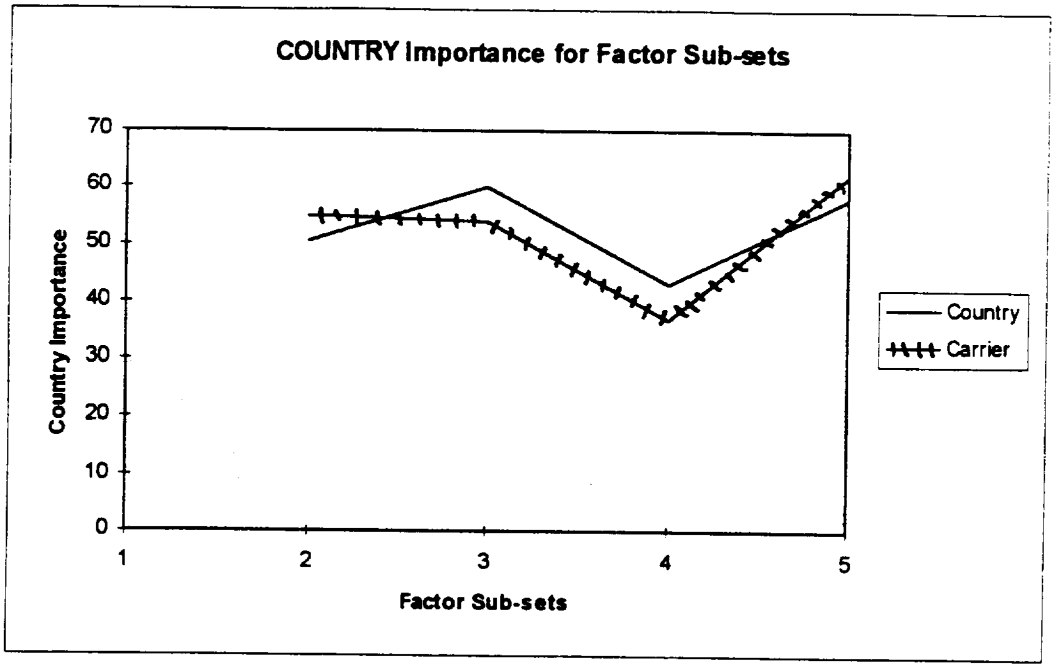

PRICE Importance for Factor Sub-samples
Price Importance
50
45
40
35
30
25
20
15
10
5
0
1
2
3
4
5
Factor Sub-samples
Country
Carrier

Figure 4



COUNTRY Importance for Factor Sub-sets
70
60
50
40
30
20
10
0
Country Importance
1
2
3
4
5
Factor Sub-sets
Country
Carrier

Figure 5

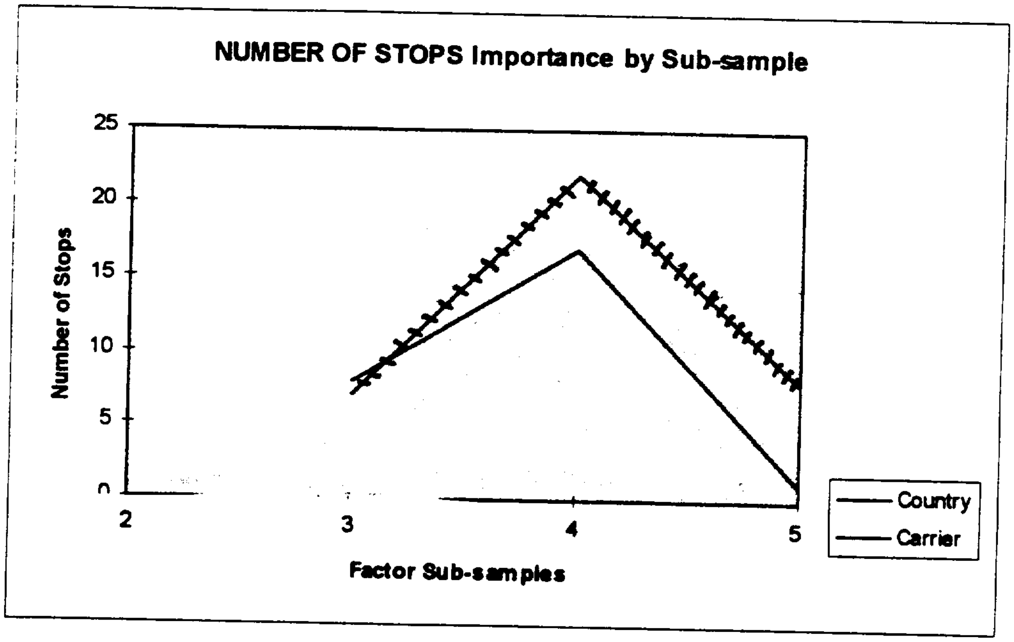
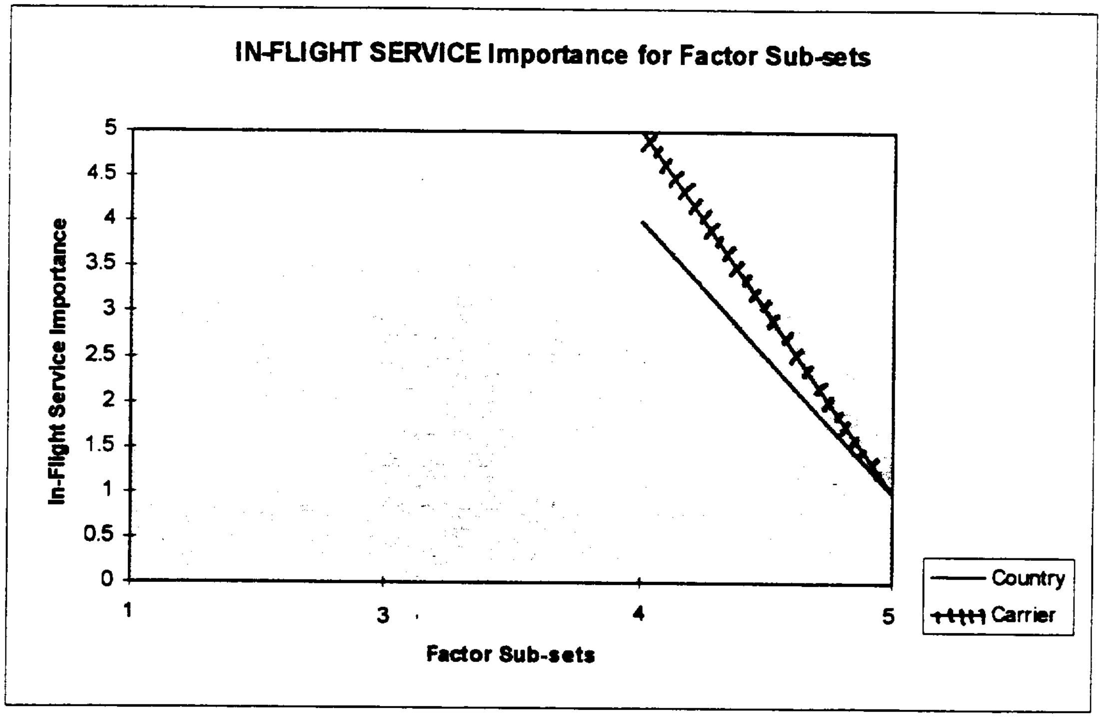
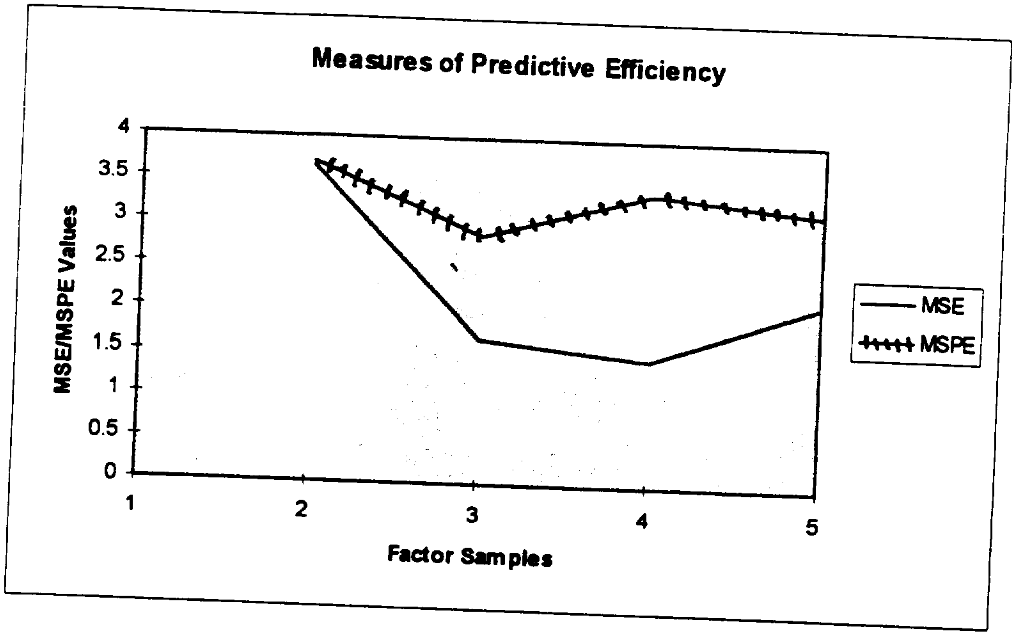

NUMBER OF STOPS Importance by Sub-sample
25
20
15
10
5
0
Number of Stops
2
3
4
5
Factor Sub-samples
Country
Carrier

Figure 6



IN-FLIGHT SERVICE Importance for Factor Sub-sets
In-Flight Service Importance
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1
3
4
5
Factor Sub-sets
Country
Carrier

Figure 7


Measures of Predictive Efficiency
4
3.5
3
2.5
2
1.5
1
0.5
0
MSE/MSPE Values
1
2
3
4
5
Factor Samples
MSE
MSPE

ANALYSIS ON THE AIRLINE NETWORK EXPANSION AND ITS INFLUENCES ON THE PASSENGERS IN THE ASIA-PACIFIC REGION

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1. Introduction

The international aviation service in the Asia Pacific region has improved with the increasing demand in accordance with economic growth in Asian countries. The international aviation network in this region, which has not been sufficiently studied for making the international aviation policies, is the focus on this study. Some aviation policies might produce undesirable results for users because of decrease of service level. The purpose of this paper is to analyze international aviation network quantitatively in terms of airline network structure and user benefit.

Firstly, the relationship between airline networks is examined considering airport pairs which are served by airlines. The airports and routes of each airline determine the relationship. Two indices that express respectively the degree of competition and the degree of complementation between networks are proposed in this study. The fact that the recent improvements of the international aviation network in this region have changed mutual relationships is demonstrated using these indices. Actually, such improvements of network affect the travel behavior of passengers. Therefore, it is necessary to consider the passenger evaluation of the change of network design.

The international service choice models that show the differences of preference for international aviation service such as fare, frequency and time are estimated by passenger's nationalities. The user benefit which is derived from the willingness to pay for the service changes is then calculated. One case study considering the Japanese, the Korean and the American passengers is undertaken to measure the user benefit for the recent service change by the major airline companies.

2. Review of related papers

In the last 15 years, a number of studies focusing on air transportation networks were conducted in the world. From the view point of demand analysis, Oberhausen et.al.(1982)[1] focused on passenger demand by means of time-series analysis. Harvey(1987)[2] analyzed air passenger behavior and proposed the hierarchical structure of passenger behavior. Morichi et.al.(1989)[3] analyzed not only international air passengers but also domestic air passengers to evaluate air transport policies in Japan. In their study, three kinds of model such as trip production model, departure airport model and trip generation model were developed to explain international passenger travel behavior. The last model was utilized to forecast induced demand using accessibility variable which varies according to level of service of each airport. They carried out one case study treating Fukuoka-Hong Kong city pair to evaluate the effect of flight frequency change and proposed increase of the international flights from/and to local airports in Japan order to decentralize the flights at Narita airport. Furuichi et.al(1994)[4] developed integrated forecasting models for international air passenger demand using discrete choice models and air passenger survey data in Japan. The passenger demand in neighboring countries must be considered when the international aviation policies and the network design problem are evaluated, however, the last two studies analyzed only Japanese travel behavior. Similarly, Kuwang Eui et.al.(1996)[5] analyzed the travel behavior of Korean passengers in terms of airline service choice using stated preference data for the services. On the other hand, Yai et.al(1995)[6] insist the necessity of research considering multi-national characteristics of passengers in order to evaluate the international aviation policy.

A research on the Asia-Pacific aviation market was conducted by Hansen et.al.(1990)[7]. The impacts of demand growth and the influences of high terminal costs of Narita Airport are mainly analyzed. The results of their simulation indicated that the increase of passenger demand would make it possible to operate intercontinental direct flights not via Narita and that the alternative Asian airports would become major gateways because of high operation costs at Narita.

As we mentioned above, the studies on the evaluation of network structure have been done mainly through the analysis of demand and travel behavior.

What seems to be lacking, however, is the analysis of network structure as products of airline companies.

The network design problem is examined by Kuby et.al(1993)[8], however, only the fleet network is dealt in his study. Hansen(1990)[9] examined the airline competition using game theory to analyze the effect of hub-domination.

In this study, then, international aviation networks as the products of airline companies are analyzed and, competition and complementation between networks are examined. Furthermore, the influence of network change on the passengers is examined in terms of the use benefit considering multi-national characteristics of passengers.

3. Network Competition and Complementation

Recently, the international aviation network in Asia has been expanding with increasing international passenger demand. Actually, this network expansion came as a result of the decision of airlines to increase their services under some conditions such as capacity constraint at airports and bilateral aviation agreements, and it was supposed that the convenience for the passengers has been significantly improved. However, there are many factors such as airline alliances and movements towards open sky policy that might lead to the drastic change of network structure, and there is a necessity of quantitative evaluation of the relationship between networks. In this chapter, the transition of relationships between airline networks are examined. The network structure could be expressed in terms of two properties. One is scope of the network and other is density of the network. When these two properties are applied to the airline network, the former one is expressed by the number of airports where the airline has flight services and the later one is expressed by the flight frequency of an airport or a specific route per unit time.

Firstly, the characteristics of network expansion are deduced by comparing the transition of the airline network structure. Then, the changes of relationship between airline networks caused by expansion are analyzed. Two simple indices represent mutual relationship between airline networks. One is the competition index and the other is the complementation index. These indices are measured using the number of airport OD(Origin-Destination) combinations of each airline network.

3.1 Historical Expansion of Airline Network

The change in the scope and density of network are examined using the OAG[10]. The flights originating from the airport where an airline uses it as its base are analyzed. Figure-1 shows the change in the number of cities served by each airline and Figure-2 shows the change of international flight frequency.

Initially, the transition in the number of airports is explained. SQ (Singapore Airlines) and CX (Cathay Pacific Airways) which use Changi Airport and Kai Tak Airport, respectively, as hub airports have actively increased their number of airports within their respective airline networks. On the other hand, it can be noted that JL (Japan Airlines) has almost no change in the number of served airports. The reasons are that capacity constraint of Narita has hindered the increasing of frequency and that high operation costs have prevented JL from operating low-demand routes.

Next, the transition of frequency is explained. The increasing trend has been evident in recent years.

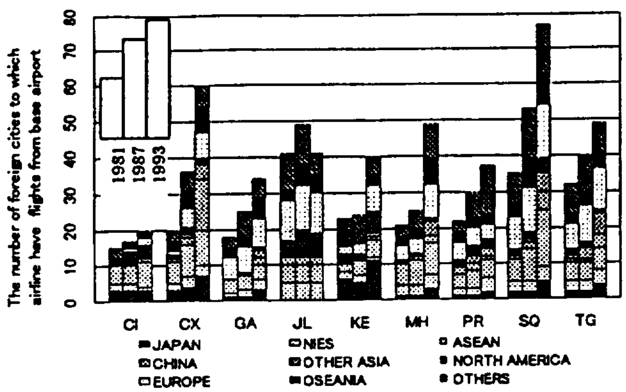


Figure-1 The change in the number of cities served by major Asian airlines and its location

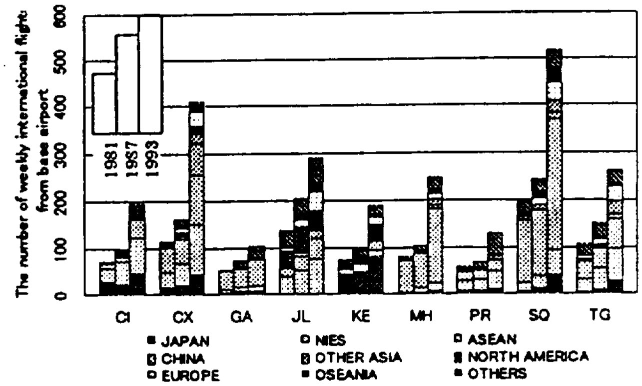


Figure-2 The change in the number of flights operated by major Asian airlines and its destination

Among these ten airlines, SQ and CX are noted to have high-frequency service. JL has improved its service through increasing frequency on existing routes without increasing the number of airports served.

The transition of network expansion are analyzed by region and are subsequently compared. JL's share of service to the U.S. and Europe is extremely larger than any other airline. In 1993, 44% of airports and 30% of frequency of JL operation are related to western countries. This indicates that the expansion of JL network has mainly spread to the long distance regions.

At the same time, KE (Korean Airlines) and OZ (Asiana Airlines) have promoted internationalization of local airports in Japan. The ratio of KE services to Japan has increased up to 28% (1993) for all airports in abroad in which KE has services, and 42% (1993) of total frequency from the airport where it is based.

Likewise, SQ has significantly improved its level of service to ASEAN countries from 1981 to 1993. The number of cities in ASEAN countries served by SQ has increased from 6 to 16 and the number of flights also has increased from 137 to 274 per week. SQ has built hub and spoke network with Changi airport as the hub.

CX's service level to China is high relative to other airlines. It is mainly due to Hong Kong (Kai Tak Airport) is one of the gateways to Chinese cities.

The ways of network expansion are different among airline companies. It is supposed that these differences affect relationships between networks largely in terms of network competition and network complementation.

3.2 Relationship between Networks

The mutual relationship between networks is explained by 4 typical cases in Figure-3. The linkage between networks in terms of nodes defines the relationship. The nodes represent airports in this research. The conditions of relationship are explained below:

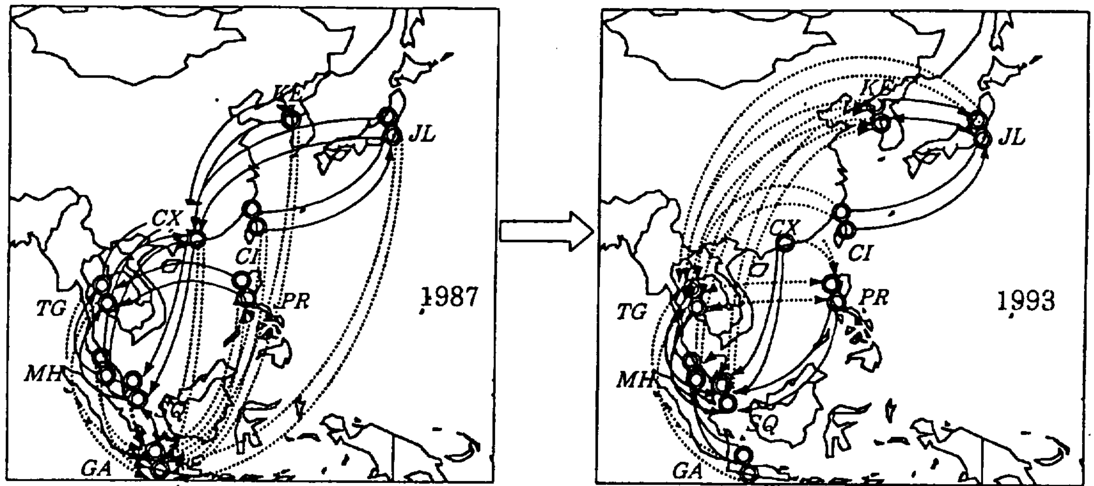
(a) **Independent networks:**
The condition where there is no common node between network A and B, that is, it is impossible to define the relationship between these networks.

(b) **Completely competitive networks:**
The condition where both network A and B are linked to all nodes, that is, it is possible to travel from one airport to other airports using only one airline network.

(c) **Completely complementary networks:**
The condition where a movement from one airport involved in network A to other airports involved in network B is not possible using only one airline network.

(d) **Inclusive networks:**
The condition where one network is completely included in another network.

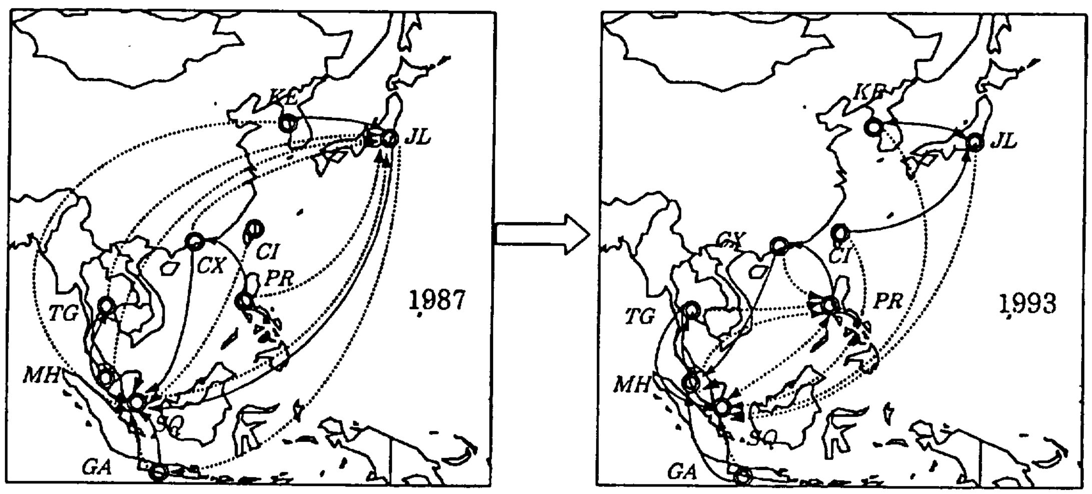
(e) **Competitive-Complementary networks:**
The condition where it is between completely competitive networks and completely complementary networks.



The most competitive network is indicated by the direction of arrow

The most complementary network is indicated by the direction of arrow

Figure-4 Competition and complementation index (boundary is Asian network)



The most competitive network is indicated by the direction of arrow

The most complementary network is indicated by the direction of arrow

Figure-5 Competition and complementation index (boundary is World)

Complementation index of network A to B is derived as a ratio of the number of airport pairs in which traveler can not move between origin and destination airports without using network A to the number of all airport pairs related to n_b. The total number of airport OD pairs related to n_b is defined as:

$$n_b(2n_a + (n_b - 1) + 2n_{ab}) \qquad (4)$$

The number of airport pairs which traveler can not move between airports without using network A and network B is:

$$2n_a n_b \qquad (5)$$

Complementation index of network A to B is:

$$2n_a n_b \;/ (n_b(2n_a + (n_b - 1) + 2n_{ab})) \qquad (6)$$

and similarly, index of network B to A is:

$$2n_a n_b \;/ (n_a(2n_b + (n_a - 1) + 2n_{ab})) \qquad (7)$$

3.4 Measurement of Indices

The indices that are developed earlier show the transition of relationship between airline networks in the Asian region. However, the competitive and the complementary condition between networks differ according to network boundary. In this study, the indices are measured in two cases, one is the case where the network boundary is the Asian region and another is the case where the boundary is the world. Figure-4 shows the competitive and complementary conditions at two points in time (1987 and 1993) when the network boundary is the Asian region. The notations in

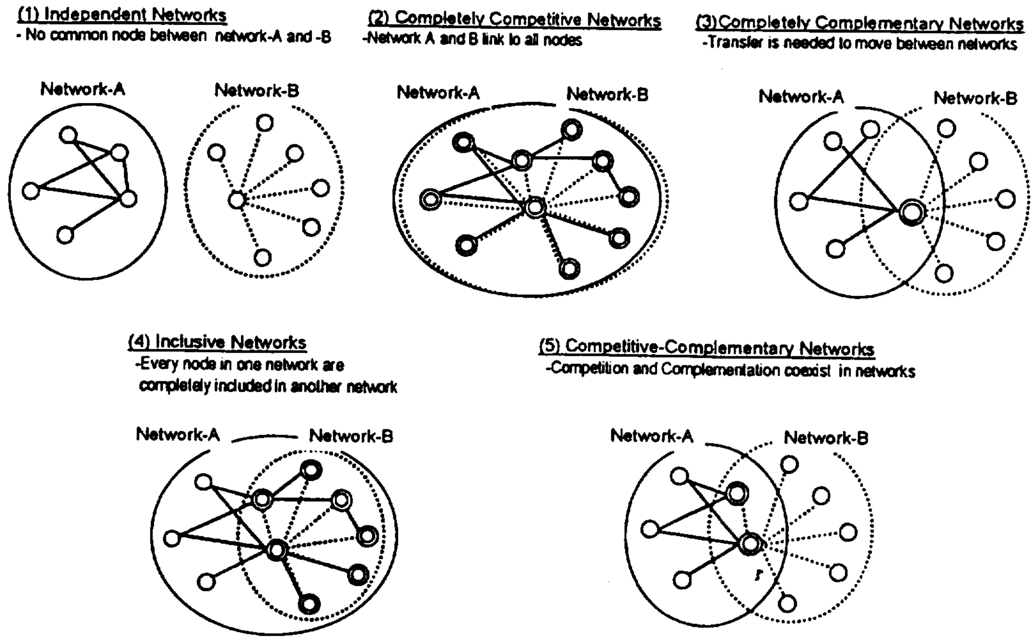


Figure-3 Relationship between networks

3.3 Network Competition and Complementation

In this section, the differences of characteristics of network expansion described earlier that change the relationship between airline networks are analyzed. For instance, if airline B enters some routes already served by airline A, there will be a new competitive condition between airlines. There are some airport-pairs where the passenger can move between them only by using airline A and airline B networks. In such case, it is considered that these airline networks are under complementary condition. Therefore, the relationships between networks of Asian airlines will be deduced by competition and complementation indices that are calculated based on data of airport OD pairs.

3.3.1 Competition Index

The competition index, which represents the competitive relationship between networks, is developed. Here, n_a is the number of airports which are included in only network A, n_b is the number of airports which are included only network B and n_{ab} is the number of airports which are included in both network A and B. The total number of OD pair combination is then derived by summing up the numbers in all cells in Table-1.

Table-1 The number of airport pairs by their attributes

		network A		network B
		n_a	n_{ab}	n_b
Network A	n_a	$n_a(n_a-1)$	$n_a n_{ab}$	$n_a n_b$
Network B	n_{ab}	$n_{ab}n_a$	$n_{ab}(n_{ab}-1)$	$n_{ab}n_b$
	n_b	$n_b n_a$	$n_b n_{ab}$	$n_b(n_b-1)$

$$(n_a+n_b+n_{ab})(n_a+n_b+n_{ab}-1) \qquad (1)$$

The number of airport OD pairs under competitive condition between network A and B is the number of OD pairs between one airport within n_{ab} and other remaining airports within n_{ab}:

$$n_{ab}(n_{ab}-1) \qquad (2)$$

The degree of competition is defined as the ratio of number of competitive OD to the number of total OD:

$$n_{ab}(n_{ab}-1)/(n_a+n_b+n_{ab})(n_a+n_b+n_{ab}-1) \qquad (3)$$

3.3.2 Complementation Index

When a traveler cannot move from one airport to another airport without using both networks A and B, the complementary condition is generated. The complementation indices between networks A and B, consist of complementation of A to B and complementation of B to A, are calculated separately.

the figure indicate not the airport but the airline. Similarly, Figure-5 shows the condition where the network boundary is the world. The node where the arrow points of the solid line and broken line indicates the strongest competitive and complementary networks for each airline, respectively. For example, the arrow of the solid line from JL to CX in Figure-4 means that CX is the strongest competitor of JL in 1987. Moreover, the arrow of the broken line from JL to GA (Garuda Indonesia) means that GA strongly complements the service of JL in 1987.

Figure-4 shows that the competitive condition changed from the state where CX is the center of the network competition in 1987 to the state where there are two centers as indicated by JL and SQ in 1993. The reason why the competitive condition has changed is that SQ has greatly increased its service to more airports focusing on Asia as earlier shown in Figure-1. Since SQ has aggressively increased the number of served cities that included also regional cities in Southeast Asia, the number of airport pairs that are under competition between SQ and other airlines has also increased. In contrast to SQ, CX had a different strategy of network expansion where CX has opened many routes to Chinese cities which consequently decreased the competitive index.

The change of the relationship with respect to complementation is then considered. Figure-5 shows that GA was the center of complementary condition in 1987 when the boundary is limited to Asian region. This is because the domestic aviation network in Indonesia has been developed and only GA served those cities. The figure shows that various complementary relationships existed in 1993. Since the KE and OZ networks have spread to Japanese local cities and CX network has spread to Chinese cities distinctively, the complementation indices of these airlines.

In Figure-5, when the network boundary is all over the world, the condition changed from the state where SQ and JL acted as centers of complementary relationship in 1987 to the state where SQ and PR (Philippines Airlines) became centers in 1993.

It is shown that the network provisions that the airlines had developed in recent years have changed the mutual relationship of networks by using the simple indices proposed in this study. Moreover, the influence of the deregulation for international air transport in each country, the movement towards the open sky policy and airline alliances and mergers which are factors that generate drastic network structural changes in the Asia-Pacific region can be evaluated by utilizing these indices.

4. Network Expansion and Its Influence on the Passengers

4.1 Network Expansion

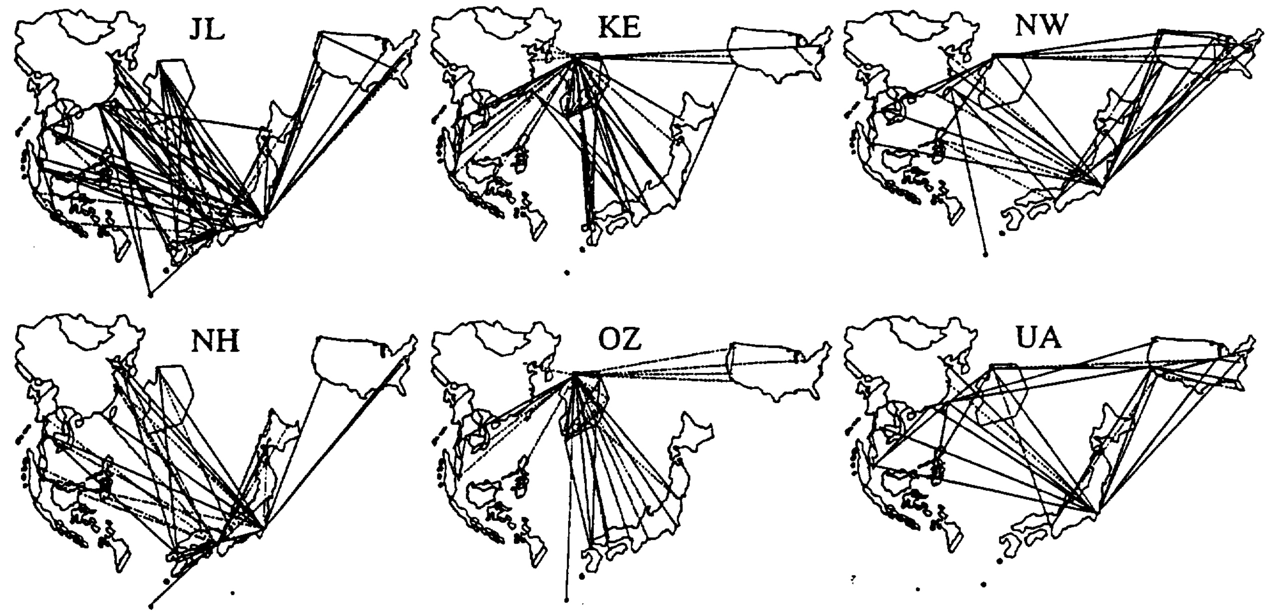
In this chapter, the effects of the international air network provision in recent years are analyzed from the airline side and the user side viewpoints. The objective to be evaluated in the change of network structure is the trend of aviation service from 1991 to 1996.

Six airlines such as JL, NH (All Nippon Airways), KE, OZ, UA (United Airline), NW (North West Airline) are considered as the suppliers. Figure-6 shows the network structure in the Asia-Pacific region of the six airlines. The routes, which were already operational in 1991, are indicated by broken lines and the routes which became operational within 1992 to 1996 are indicated by the solid line.

The airline networks, which have been expanding in these five years, are identified as NH, KE and OZ. NH has increased its service to cities with the opening of Kansai International Airport. Meanwhile, KE and OZ have opened new routes to local cities in Japan.

4.2 Transition of Network Competition and Complementation

In this section, we set the network boundary to the Asia and the United States. Then, the relationship among six airline networks can be shown by the proposed indices. The international and domestic services of Korean airlines, and the international service and domestic service related to the Narita and the Kansai airports of Japanese airlines are considered in order to measure the indices. Only the international routes concerning the transpacific services are



The route which was operated in 1991

The route whose operation started between 1992 and 1996

Fiqure-6 Network expansion of 6airlines (JL.NH.KE.OZ.NW.UA)

Table-2 Competition Index

91＼'96	JL	NH	UA	NW	KE	OZ
JL	＼	0.22	0.15	0.14	0.21	0.15
NH	0.19	＼	0.07	0.08	0.11	0.07
UA	0.20	0.06	＼	0.38	0.07	0.07
NW	0.18	0.04	0.32	＼	0.08	0.11
KE	0.19	0.10	0.07	0.06	＼	0.21
OZ	0.05	0.03	0.04	0.03	0.11	＼

Table-3 Complementation Index(1991)

positive side＼ passive side	JL	NH	UA	NW	KE	OZ
JL	＼	0.41	0.49	0.43	0.32	0.68
NH	0.20	＼	0.53	0.48	0.31	0.66
UA	0.11	0.39	＼	0.13	0.28	0.58
NW	0.23	0.48	0.32	＼	0.38	0.66
KE	0.32	0.49	0.59	0.55	＼	0.62
OZ	0.20	0.36	0.40	0.36	0.09	＼

Table-4 Complementation Index (1996)

positive side＼ passive side	JL	NH	UA	NW	KE	OZ
JL	＼	0.33	0.56	0.46	0.20	0.39
NH	0.26	＼	0.60	0.50	0.27	0.44
UA	0.11	0.25	＼	0.05	0.12	0.25
NW	0.26	0.37	0.35	＼	0.25	0.32
KE	0.40	0.51	0.67	0.59	＼	0.42
OZ	0.35	0.46	0.61	0.47	0.19	＼

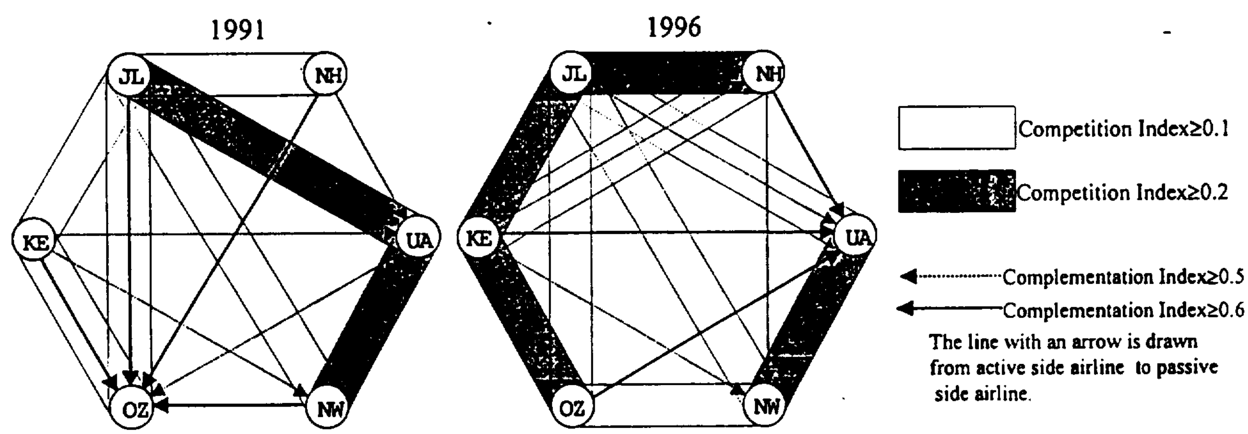


Figure-7 The change of relationships among 6 airlines

considered for the American airlines.

Table-2 shows the results of competition index between networks and Table-3 and Table-4, respectively, show the complementation index in 1991 and in 1996.

Moreover, Figure-7 displays only the network relationship with high value and it is clean that the expansion of network has generally made the relationship highly competitive. The figure shows that the situation has changed from the condition where only JL is the core of network competition in 1991 to the condition where Japanese and Korean airlines are the cores in 1996. The reason is that Korean airline companies have aggressively provided new routes to many cities in Japan where Japanese airlines are already operating.

who depart from Tokyo and Osaka, the transit of flights is not considered in this research. Also, the Korean passengers who depart from Seoul and transit in Kansai Airport are not considered.

The airports of Los Angeles, San Francisco and Seattle in the U.S., Seoul in Korea, and all airports in Japan connected to Narita or Kansai are considered in the measurement of user benefit. Therefore, the number of Japanese passengers who entered the U.S. through the airports located in the West Coast and the number of American passengers who departed from that region are used for measuring the total user benefit.

Figure-8 shows the total annual user benefit and user benefit by destination. Total benefit is shown in terms of circles on each region and the lines show the benefit according to the destination wherein the arrow indicates the destination. The white circle shows the decrease of benefit and shaded circle shows the increase of benefit. The figure shows that the user benefit decreased in the prefectures located in Eastern Japan, including Tokyo. The main reason is that the number of flights not only between Narita and the West Coast but also between Narita and Seoul decreased in these five years. It shows that the effect of the opening of Kansai International Airport and the internationalization of local airports overcame the benefit deficit, which influenced all prefectures in Japan.

The level of convenience of trips from local cities in Japan to the United States by way of Seoul has improved largely, although there was no schedule of connecting flights in Seoul within the same day in 1991.

The large difference in the total user benefit between Japanese passengers and Korean passengers became evident. The reasons are that the willingness to pay for the service improvement is different due to the difference of model parameters and that the annual passenger demands are largely different.

The total user benefit of passengers from the West Coast to Japan decreased. The main factor is that the service of JL between Narita and Seattle came to an end.

However, since the service that connects these three countries is limited to six airlines and the level of service is actually much improved, the decrease of benefit did not occur.

The relationship between the competition index and the user benefit is then examined. The tendency wherein the user benefits increase by the intensification of competitive condition is elaborated here. It can be understood by the fact that the decrease of the competitive condition occurred only in the relationship between Japanese airlines and American airlines and that the decrease of user benefit happened for passengers departing from the West Coast to Japan.

It was demonstrated that measuring user benefits due to the effects of network provision and the applicability of this method to the quantitative evaluation of the network changes according to the aviation policy.

6. Conclusion

There are many factors, such as increasing demand and airport investment, introduction of open sky policy and the increasing airline alliances and mergers, which may cause drastic change in aviation network structure in the Asian region. Therefore, the possible consequences caused by the structural change of network are quantitatively analyzed in order to decide the suitable aviation policy.

In this study, the international aviation network in Asian region, where quantitative analysis is not advanced, is analyzed to evaluate its structure. Two indices that can explain the mutual relationship such as competition and complementation between networks are proposed. The international service choice models are estimated by nationalities to analyze the effects of service changes from the passenger's viewpoint.

Now, the simulation system to examine the effects of network changes in terms of network structures and user benefit is under construction. In addition, it is necessary to expand the region to be studied from three countries (Japan, Korea and U.S.) to a wider region and examine the present aviation policies.

Table-5 Service Choice model (Foreigners)

Nationality	U.S.A	Canada	EU	Korea	Singapore	China
Fare	-4.07	-4.99	-4.16	-3.68	-5.56	-4.02
(100US$)	-19.9	-7.00	-12.5	-6.15	-4.59	-4.73
Travel Time	-2.40	-3.80	-2.67	-1.36	-2.44	-1.43
(hour)	-8.18	-3.75	-5.42	-1.53	-1.55	-1.07
Frequency	0.208	0.379	0.346	0.243	0.739	0.452
ln (flights/week)	4.84	2.40	4.77	1.52	2.53	2.19
Flag of airline	0.294	0.121	0.100	-0.0316	0.272	-0.186
(own=1,others=0)	4.94	0.637	1.04	-0.170	0.871	-0.737
ρ^2	0.179	0.209	0.178	0.190	0.247	0.220
Hit ratio(%)	54.6	57.7	56.4	57.5	59.3	59.0
Num.of samples	2154	189	801	186	81	105

below:t-value

Table-6 Service Choice Model (Japanese)

	Access service		International servic	
Fare(¥10000)	-3.13	-14.7		
logsum utility of international service	0.932	5.00		
"Airport" dummy(Narita)	1.84	2.26		
"Airport" dummy(Osaka)	1.23	2.01		
"Airport" dummy(Nagoya)	2.44	3.83		
Fare(¥10000)			-0.241	-6.49
Travel Time(hour)			-0.0651	-1.34
Frequency (ln(flights/week))			1.41	18.4
Flag of airline(own=1,others=0)			0.369	4.47
ρ^2	0.776		0.105	
Hit ratio(%)	93.4		42.3	
Num.of samples	592		783	

right side:t-value

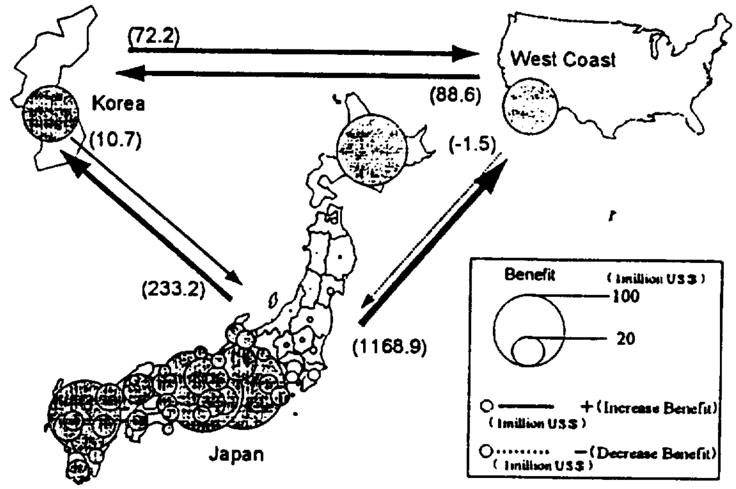


Figure-8 The change of user benefit from 1991 to 1996

Moreover, as to the complementation relationship in 1991, because OZ network is small in scale, OZ left the complementation to all the other airlines. In contrast, in 1996, the condition changed such that the US airline companies have left the complementation to the Japanese and Korean airline companies.

The transitions of the relationship between networks in terms of structure are demonstrated by the indices. Subsequently, the ability of these indices for evaluating network relations is confirmed by comparing with the actual phenomenon and by the significance of the indices. However, service frequency which is a major factor of competition is not considered while the indices were being measured. Therefore, frequency will be taken into account in the further studies utilizing the method described in this paper.

4.3 Measurement of User Benefit

The improvement of international aviation service in one airport such as the increase of flight frequency and served cities increases the accessibility of the airport. In this paper, the user benefit is measured by using the method proposed by Williams[11]. The user benefit provided by the improvement of international aviation service from 1991 to 1996 is computed in this section.

The user benefit generated by the network changes in Japan, Korea and the United States is measured.

Since the service improvement of one route affects not only the passenger who uses this route between the airports but also the passengers who travels beyond the airports after transit, it is necessary to take many classes of passengers into the evaluation parameters.

The international aviation service choice models shown in Table-5 are used for network evaluation from the Korean and American passenger's viewpoints. These model are estimated using the SP (stated preference) survey at Narita. On the other hand, the route choice and airport choice model shown in Table-6, which were estimated in our previous research, are used for the network evaluation from the viewpoint of Japanese passengers.

Here, Japanese passengers using Tokyo, Osaka and Seoul for transit are considered. For the passengers

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8)Kuby, M.J. and Gray, R.G: The Hub Network Design Problem with Stopover and Feeders", Transportation. Res.-A, Vol.27A, No.1, pp.1-12, 1993

9)Hansen M,: Airline Competition In A Hub-Dominated Environment: An Application Of Non-cooperative Game Theory", Transportation. Res.-B Vol. 24B,No.1,pp. 27-43. 1990.

10)Official Airways Guide, 1981, 1987, 1993.

11)Williams, H. C. W. L: On the formation of travel demand models and economic evaluation measures of user benefit, Environmental and planning, A 9, 285-344, 1977.

BOMBARDIER REGIONAL AIRCRAFT

New Technology Aircraft: Catalysis for Regional Market Growth

Trung Ngo

Director, Marketing Analysis - The Americas

Air Transport Research Group Conference

Vancouver, Canada

June 27, 1997

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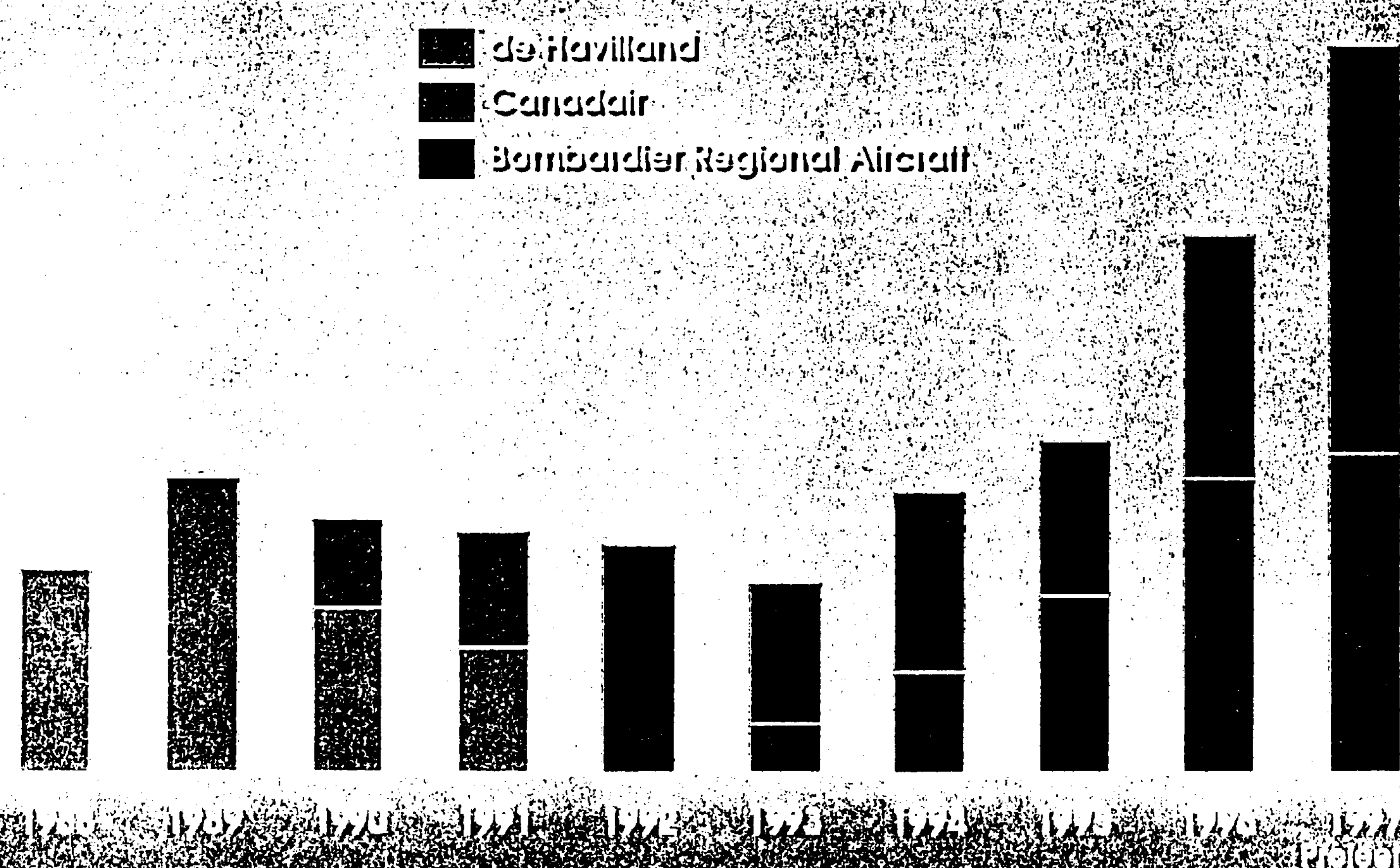
BOMBARDIER REGIONAL AIRCRAFT

Bombardier Market Share Performance



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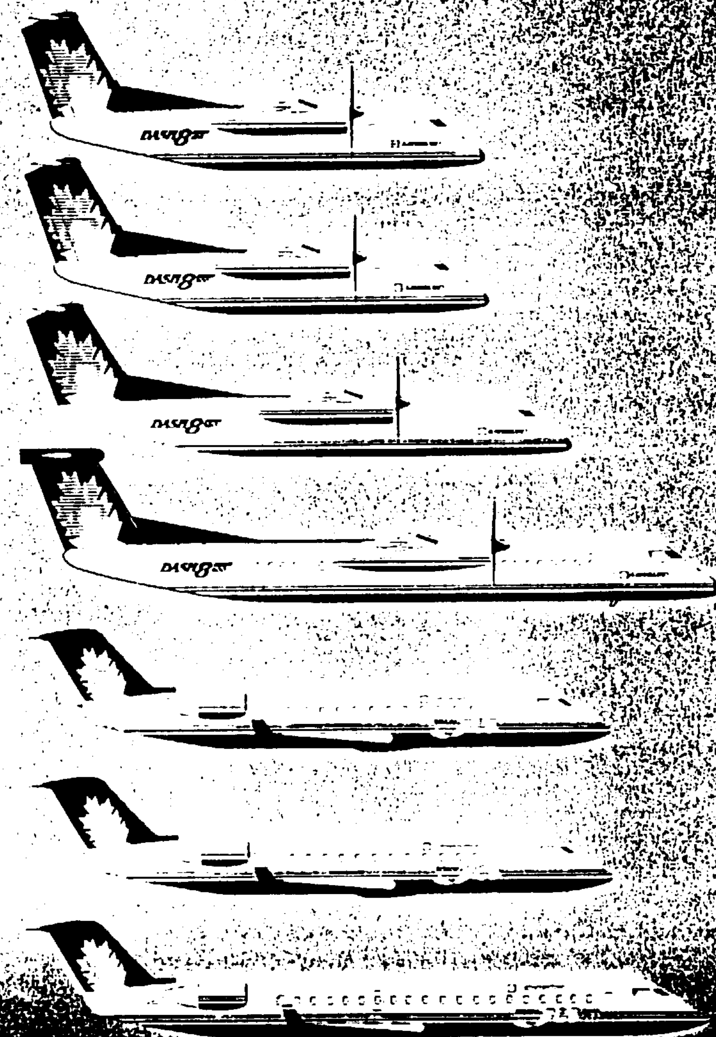
Bombardier Regional Aircraft Family



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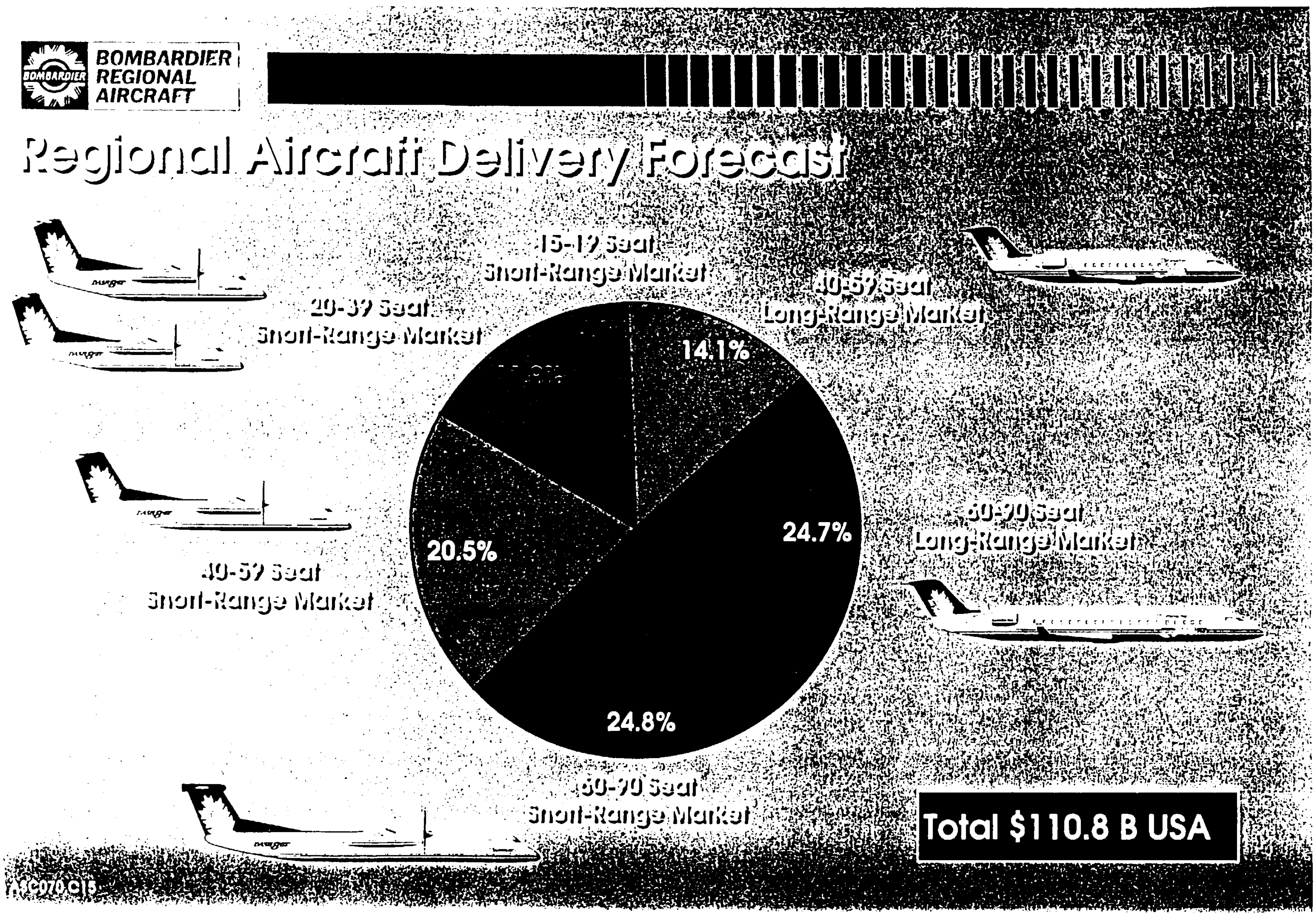

BOMBARDIER REGIONAL AIRCRAFT
Regional Aircraft Delivery Forecast
15-19 Seat Short-Range Market
20-39 Seat Short-Range Market
40-59 Seat Long-Range Market
40-59 Seat Short-Range Market
60-90 Seat Long-Range Market
60-90 Seat Short-Range Market
14.1%
20.5%
24.7%
24.8%
Total $110.8 B USA

BOMBARDIER REGIONAL AIRCRAFT

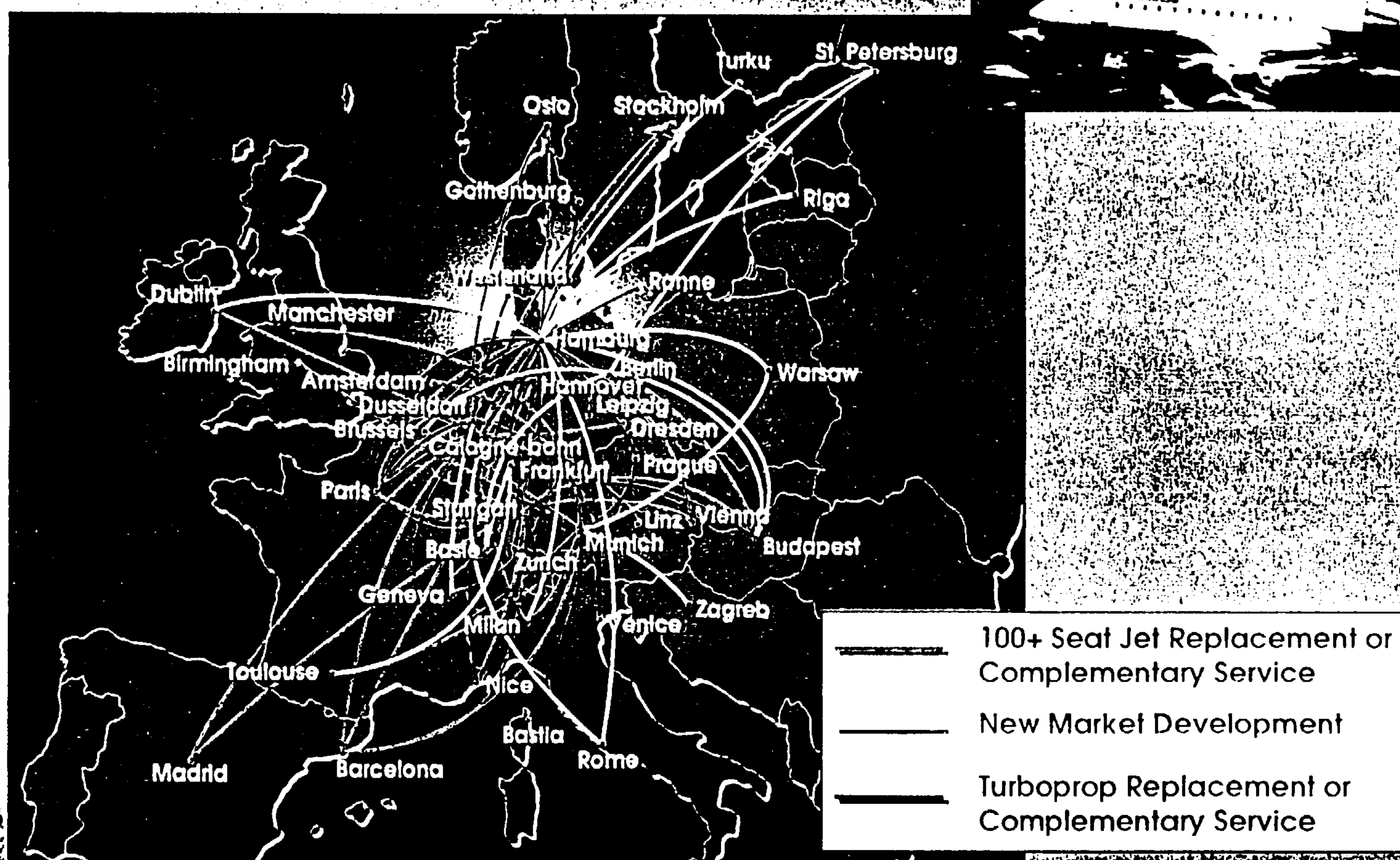
Introducing The Newest Family Member

The CRJ Series 700

BOMBARDIER REGIONAL AIRCRAFT

Lufthansa CityLine Route Network

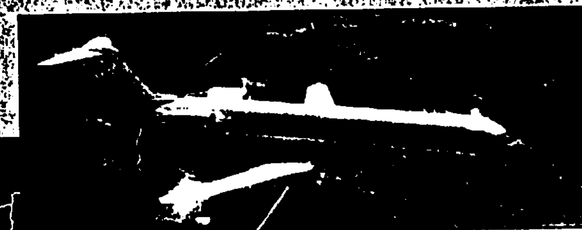
Canadair Regional Jet, August 1996

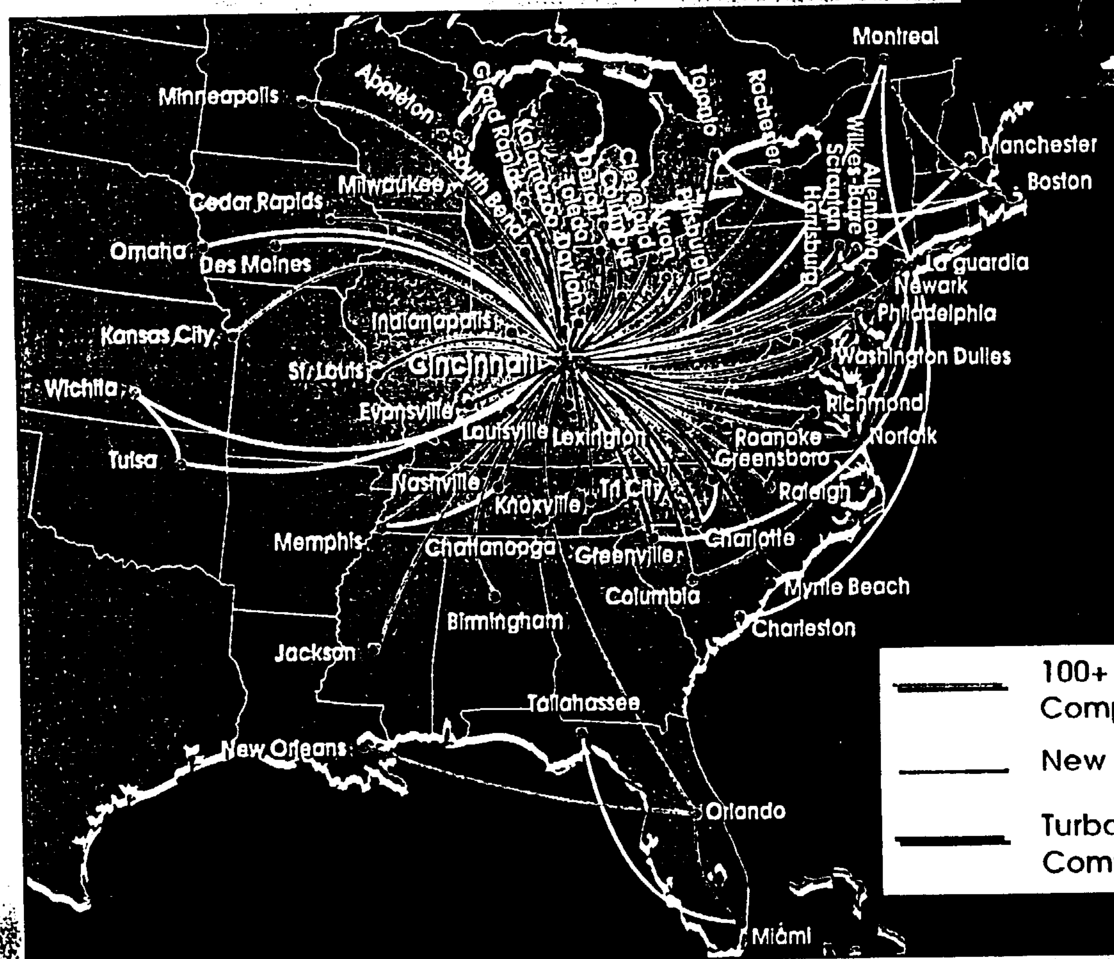


BOMBARDIER REGIONAL AIRCRAFT

COMAIR Route Network

Canadair Regional Jet, February 1997





100+ Seat Jet Replacement or Complementary Service

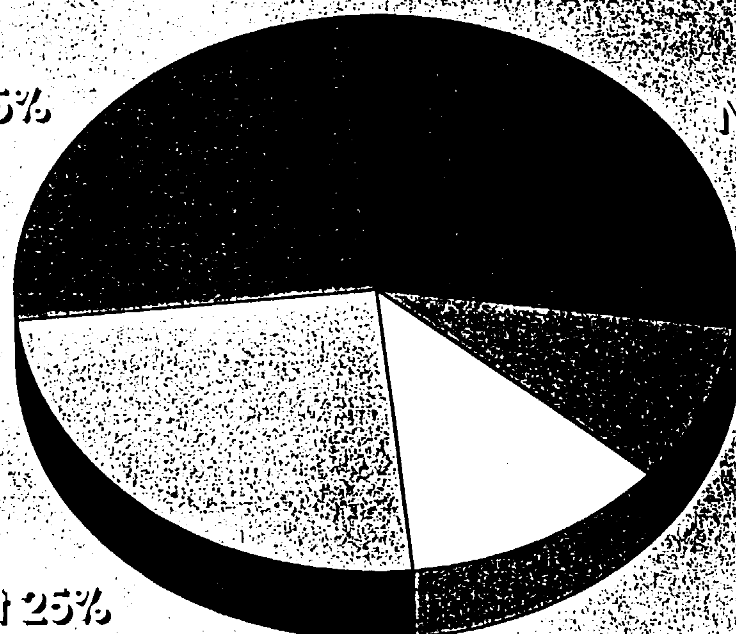
New Market Development

Turboprop Replacement or Complementary Service

BOMBARDIER REGIONAL AIRCRAFT

Canadair Regional Jet Applications

Summary of All Operators



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The Advantage of a Regional Jet in Thin Markets

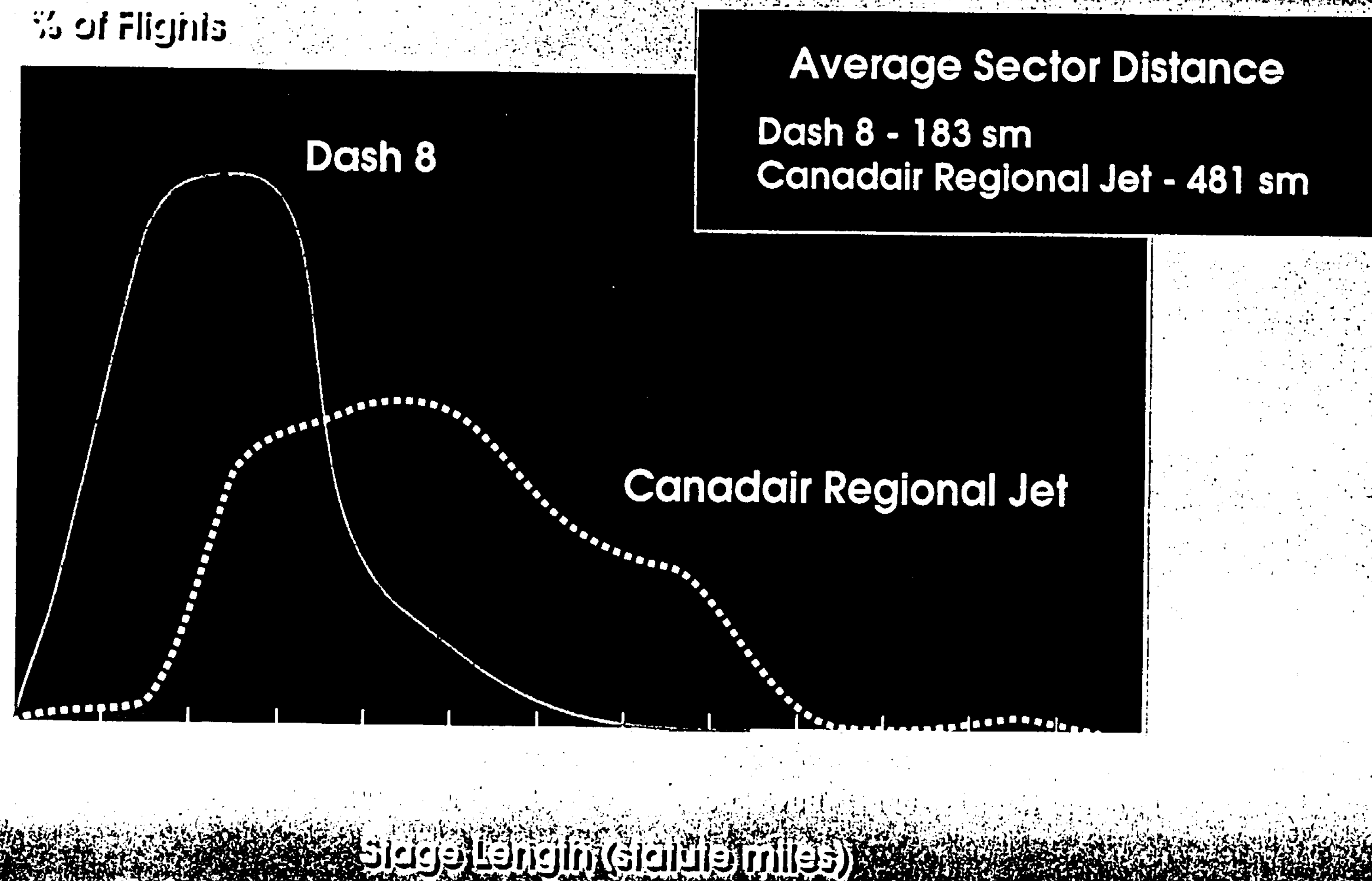
Economics @ 500 nm

	Canadair Regional Jet Series 200 50 Seats	737-300 Typical Carrier 124 Seats
Direct Operating Costs	2,124.41	4,619.94
General / Overhead	849.76	2,078.97
Total Operating Costs	2,974.17	6,698.91
Break - Even Seats	**23.8**	**53.6**
Profit (@ 30 Pax Load)	775.83	-2,948.91

BOMBARDIER REGIONAL AIRCRAFT

Worldwide Flight Distribution

Dash 8 and Canadair Regional Jet



Source: BRAD

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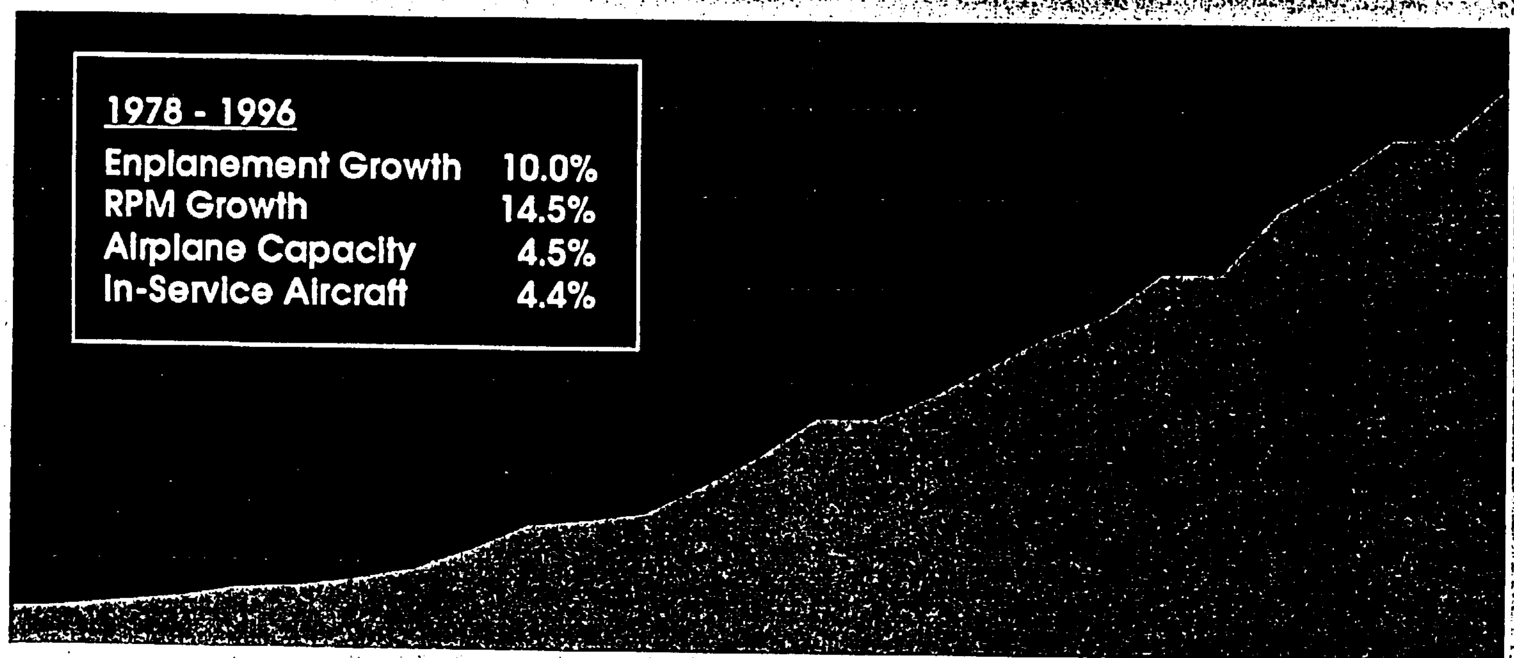
The Canadair Regional Jet

A New Technology For Sector Length Expansion

BOMBARDIER REGIONAL AIRCRAFT

U.S. Regional Passenger Traffic
1970 - 1996

Passengers Enplaned (Millions)



Year

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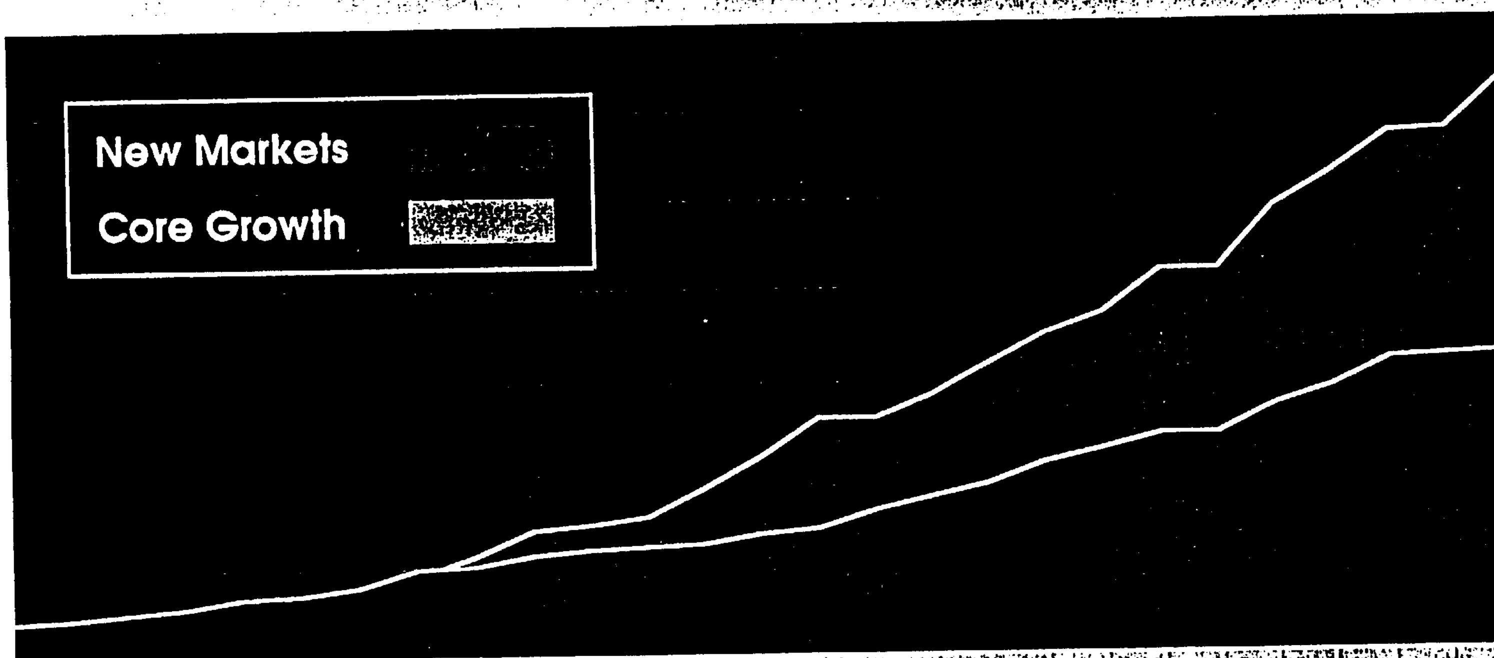
U.S. Regional Passenger Traffic

Sources of Growth

Passengers Enplaned (Millions)



Year

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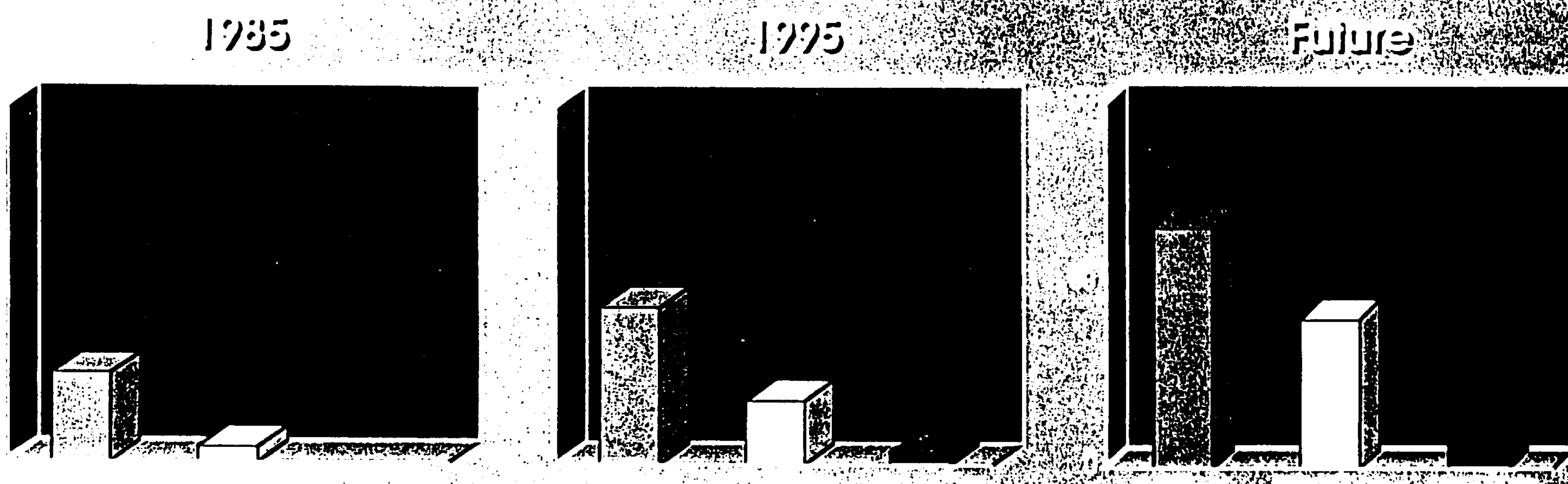
Small Airplane Market Penetration

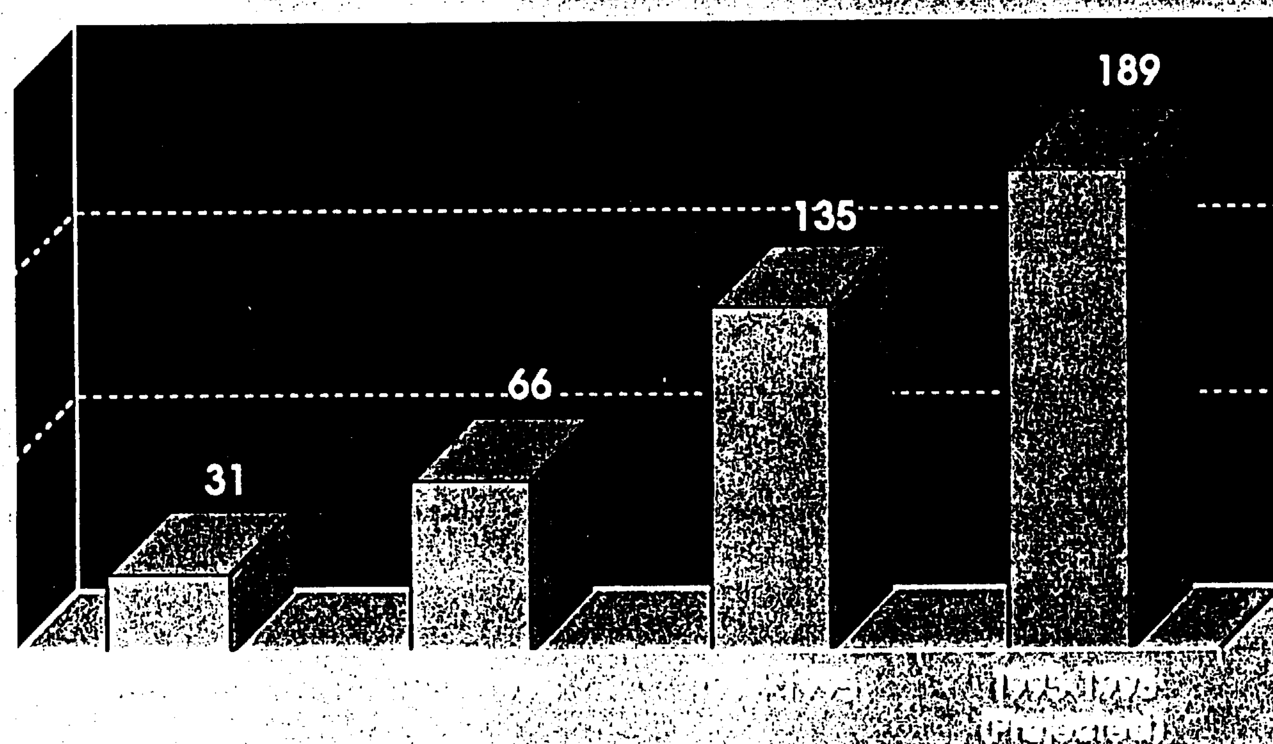
ASM Share



Robust Regional Growth Is Driven By Market Share Expansion

BOMBARDIER REGIONAL AIRCRAFT

U.S. Major Regional Airline Route Transfers

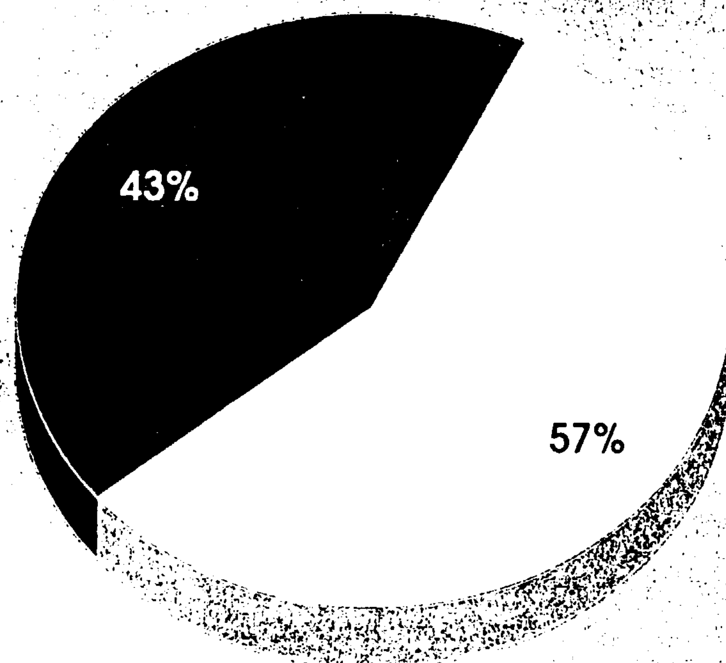


10.3 Annually	22.0 Annually	45.0 Annually	63.0 Annually

BOMBARDIER REGIONAL AIRCRAFT

U.S. Weekly Departures - 1996

Regionals
98,800 Weekly Departures



Majors
129,600 Weekly Departures

Total Weekly Departures : 228,400

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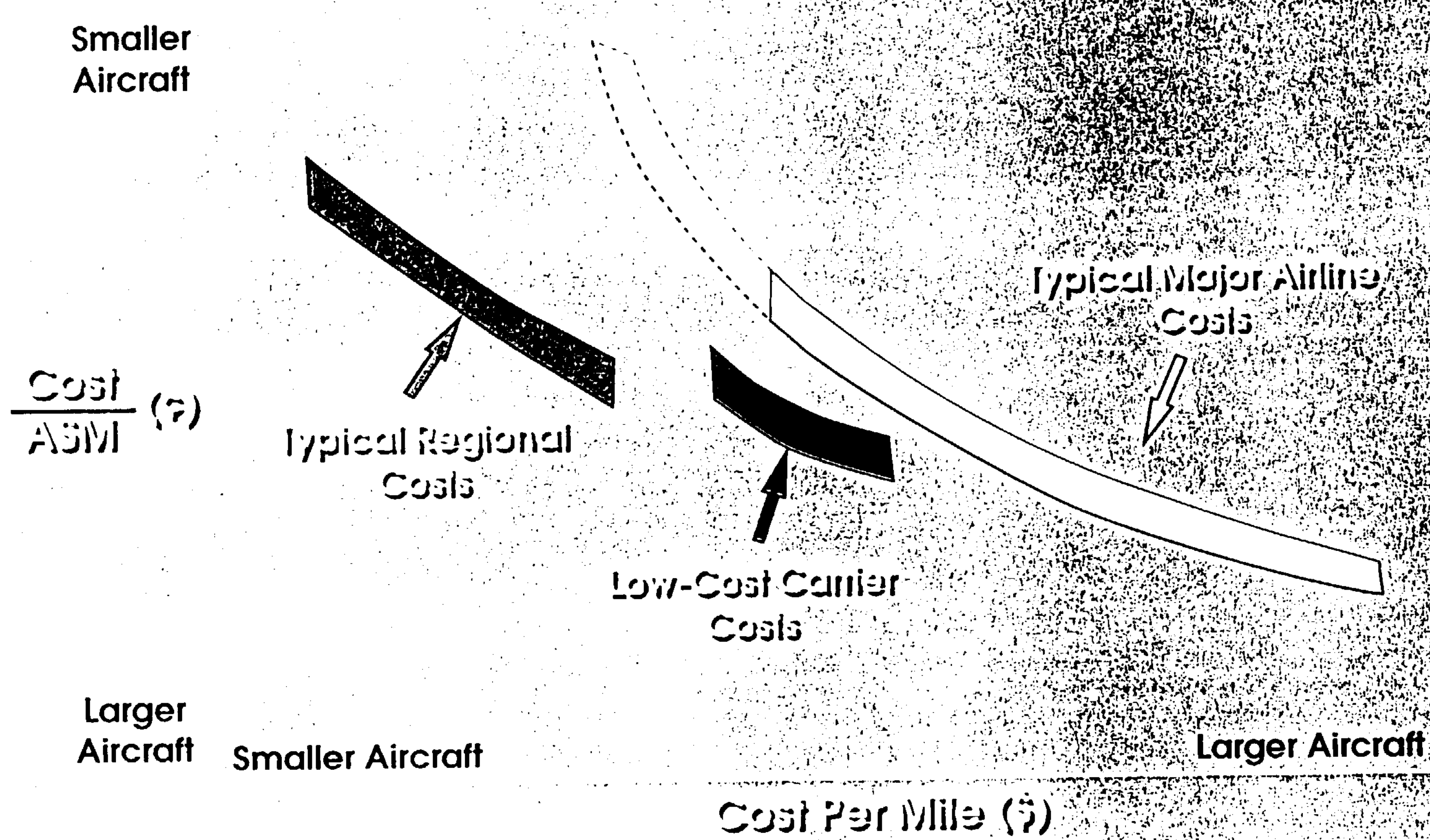
Typical North American Costs



Successful Operation Of Small Units Of Capacity Is Dependant On Low Costs

BOMBARDIER REGIONAL AIRCRAFT

Comparative Statistics for U.S. Majors and Regionals
1995 Data

	Regionals	Majors
Revenue Per Enplanement	$100.65	$133.25
Cost Per Enplanement	$75.93	$105.33
Break-Even Load Factor	42.4%	62.5%
Actual Load Factor	49.9%	67.4%
Profit Margin	12%	6%

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The Competitive Advantage Of Larger Turboprops

Economics @ 200 nm

	Dash 8/200 37 Seats	Dash 8/300 50 Seats	Dash 8/400 74 Seats	737-300 138 Seats Low Cost Carrier	737-300 124 Seats Typical Carrier
Direct Operating Costs	959.75	1106.19	1368.17	2804.93	3224.10
General/Overhead	383.90	442.48	547.28	1262.22	1450.85
Total Operating Costs	1343.65	1548.67	1915.45	4067.15	4675.75
IOC/ASM	15.75¢	13.44¢	11.23¢	12.79¢	[illegible]
Break-Even Seats	15.3	17.6	21.8	46.2	53.1

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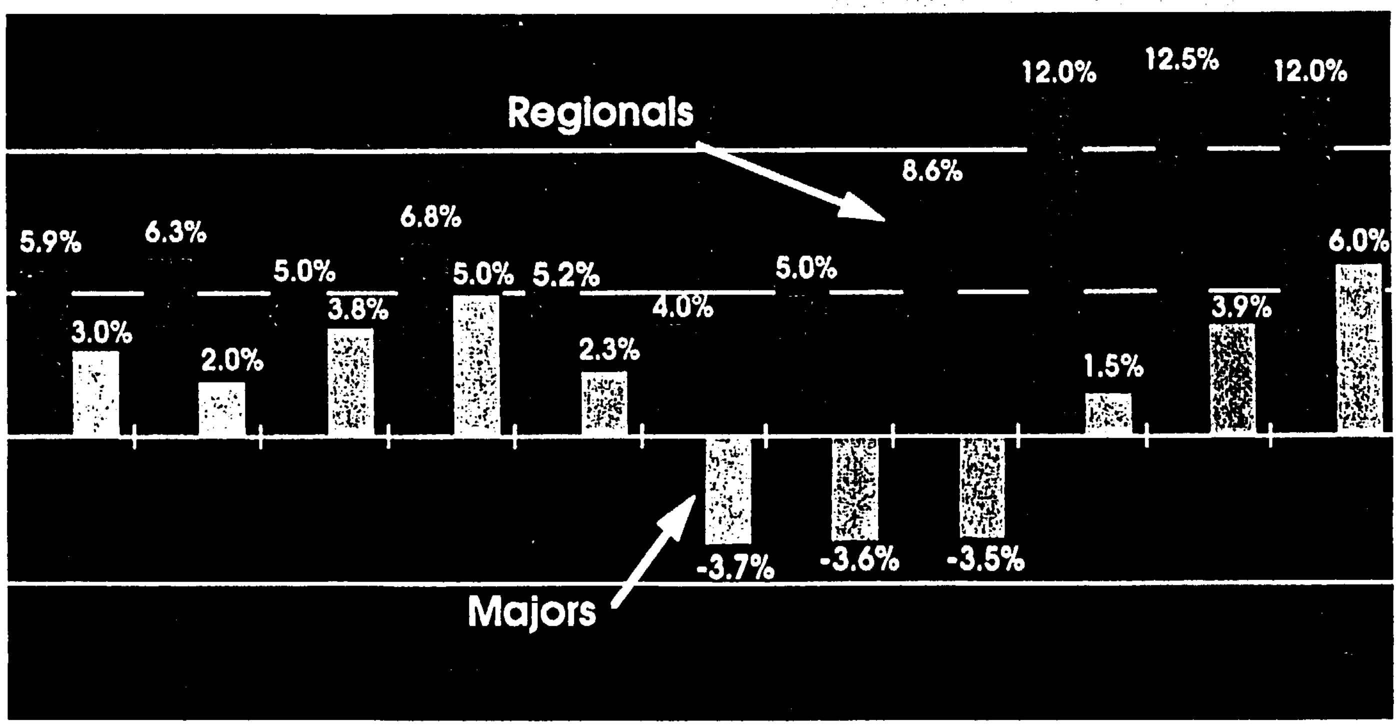
Operating Margins

U.S. Majors & Regionals

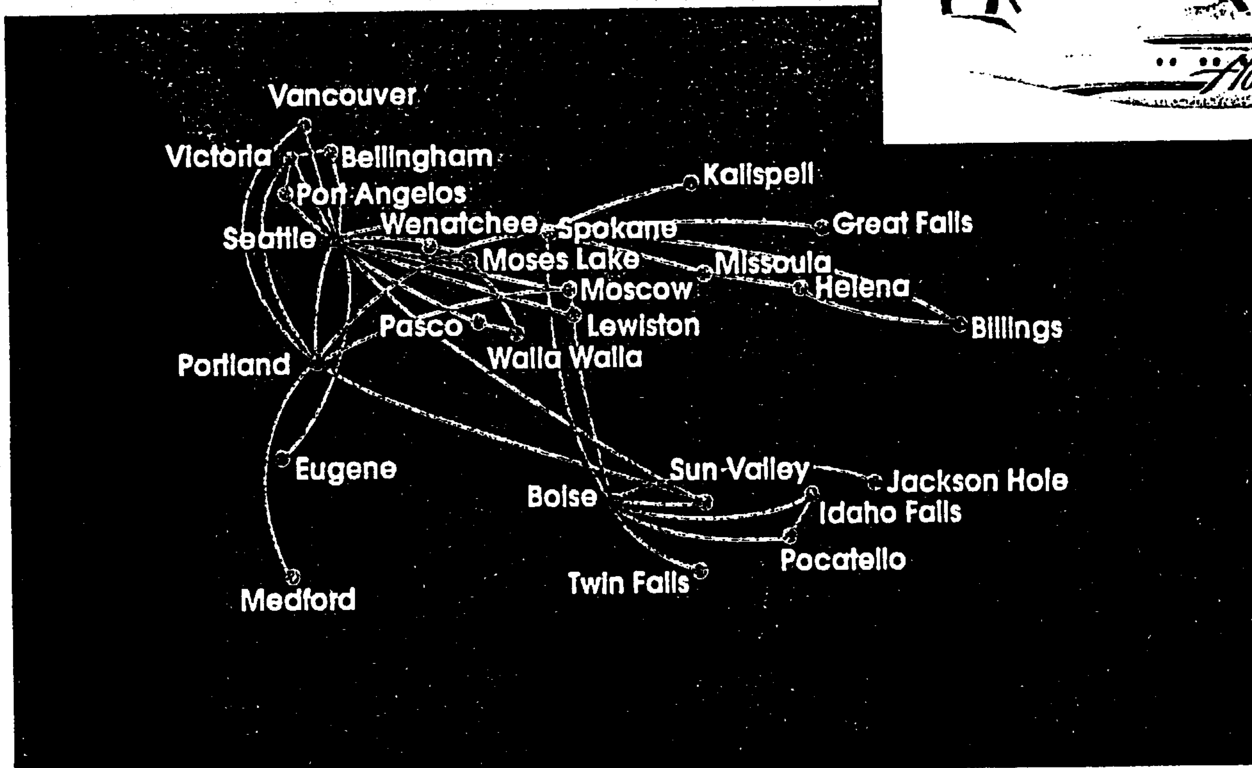


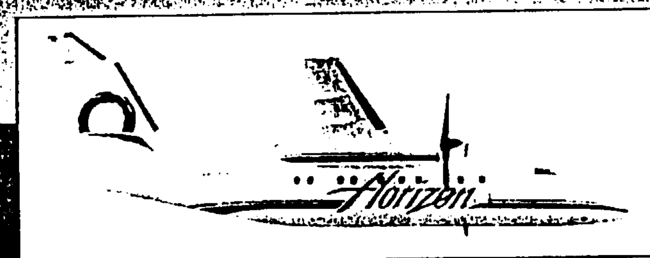
Source: Ridder Peabody/BRAD

BOMBARDIER REGIONAL AIRCRAFT

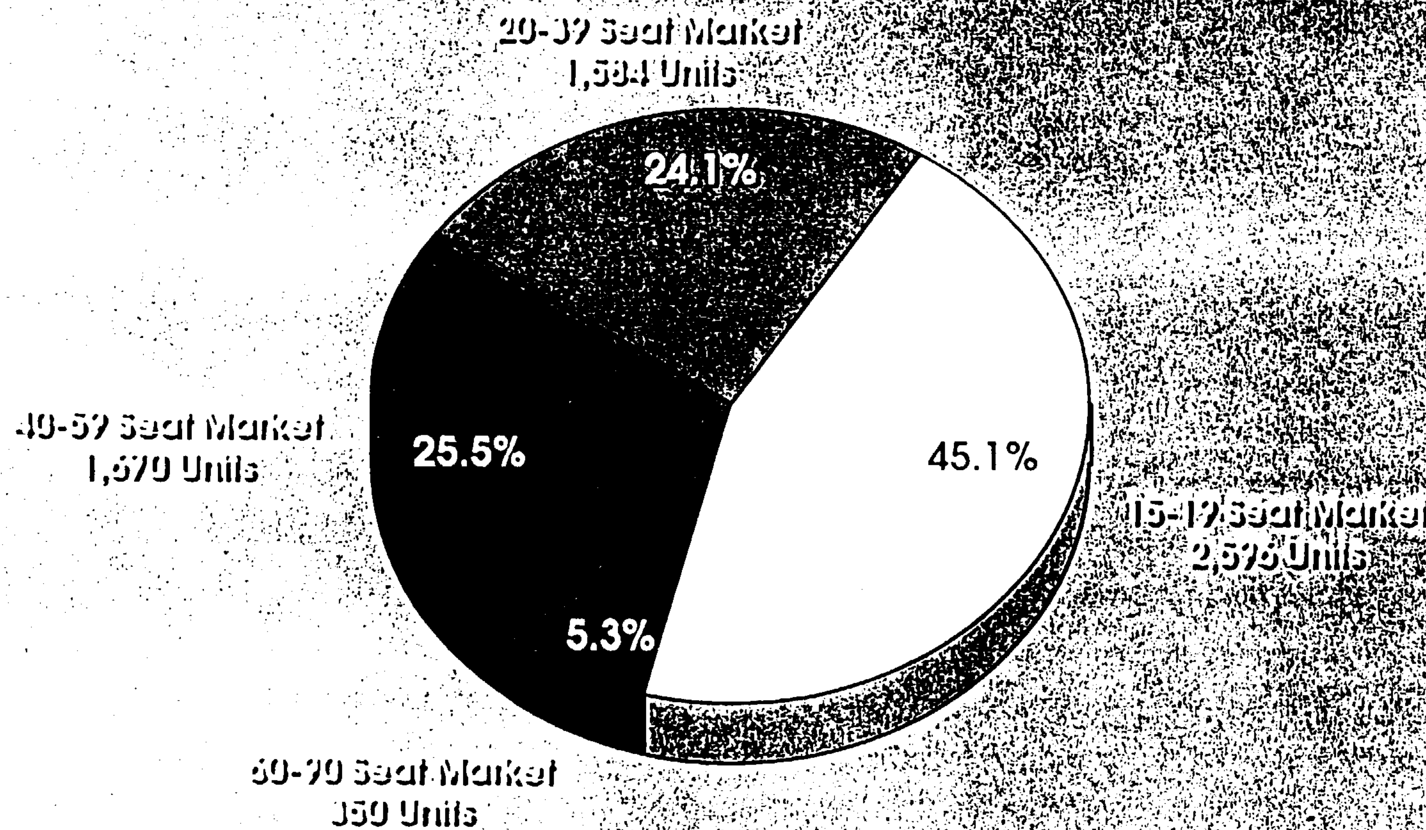
Horizon Route Network

Dash 8, February 1997





The Regional Turboprop Fleet is Very Large



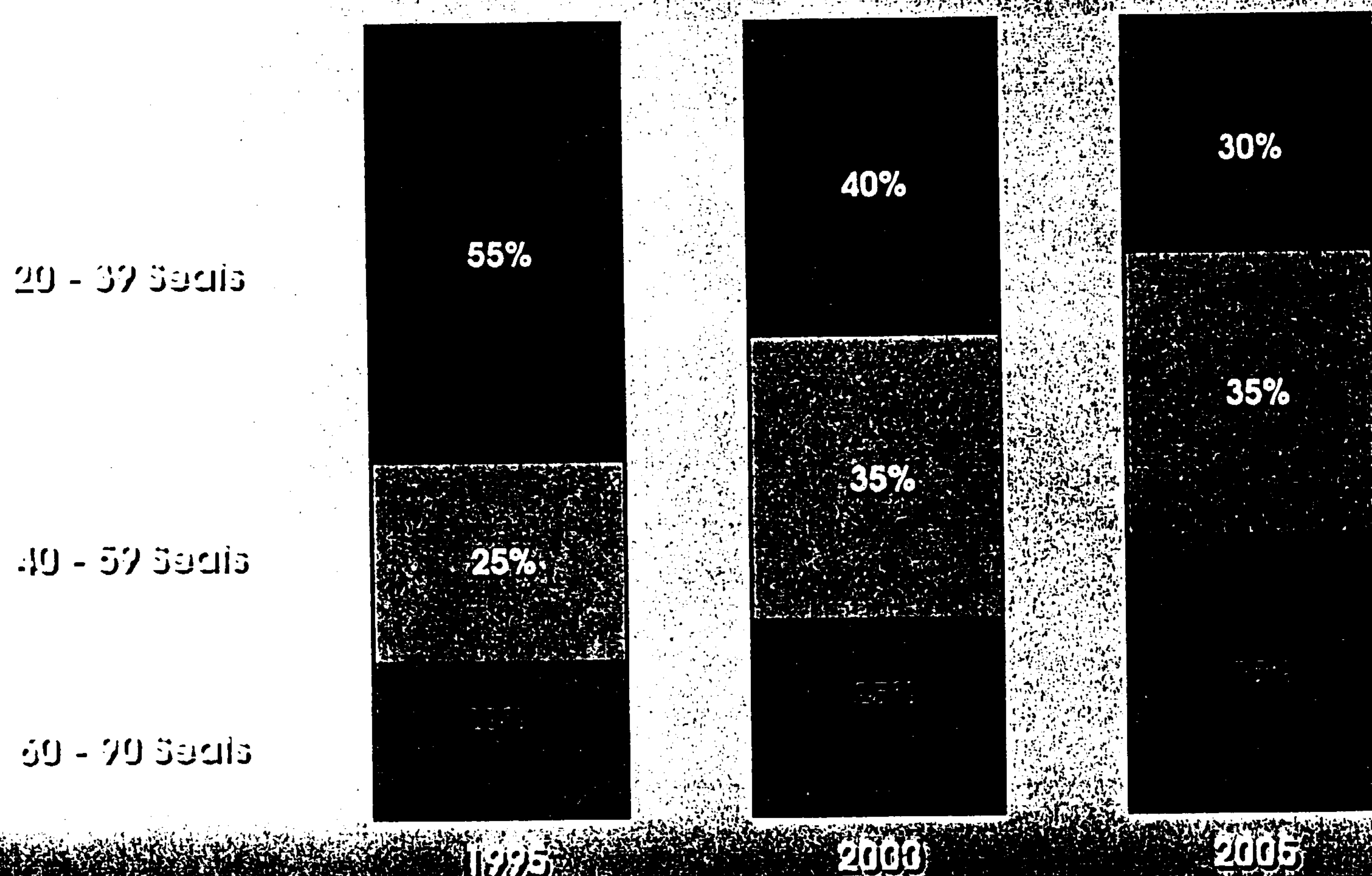
Total Active Regional Fleet: 6,560 Aircraft

Source: BRAD

BOMBARDIER REGIONAL AIRCRAFT

Regional Market Forecast

Short-Range Delivery Segmentation



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The Next-Generation 70-Seat Turboprop

The Dash 8 Series 400

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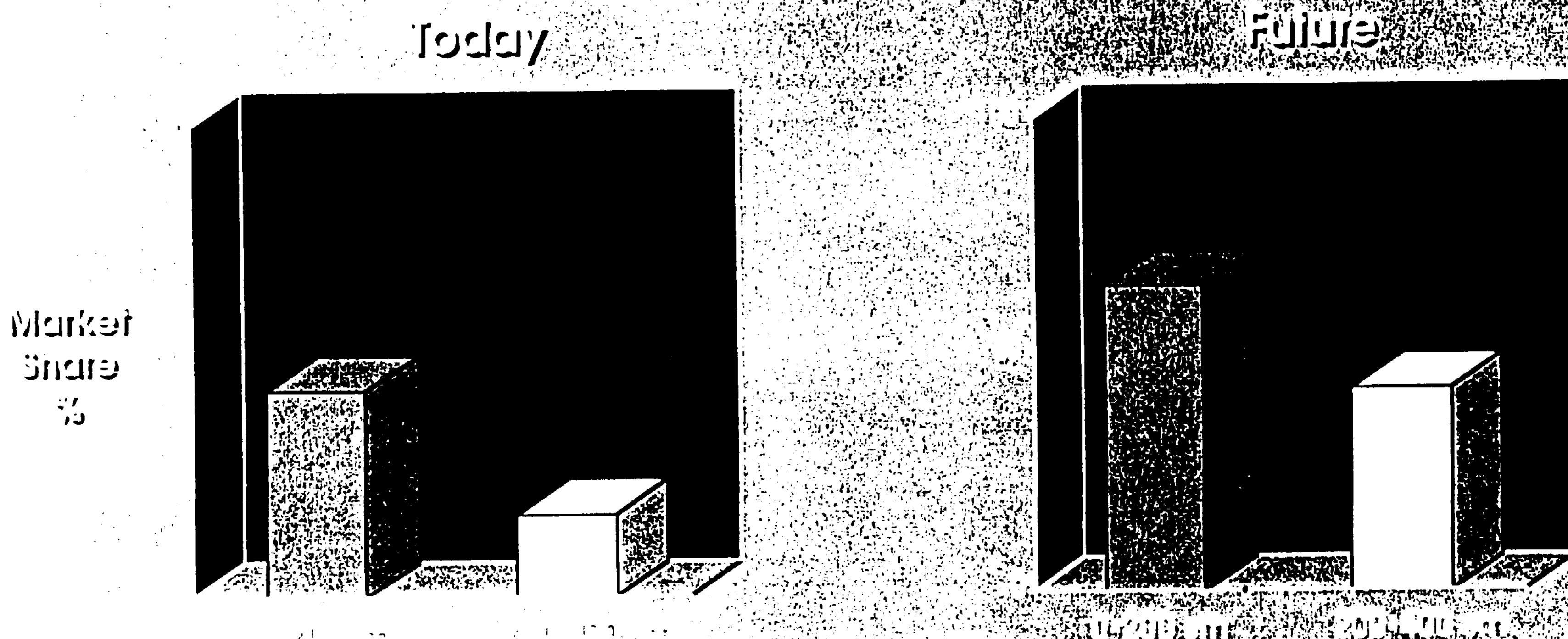
The Dash 8 Series 400 Expands The Core



The Size, Speed and Operating Cost Characteristics Will Open Substantial Market Opportunities

BOMBARDIER REGIONAL AIRCRAFT

Dash 8 Series 400: The Bottom-Line

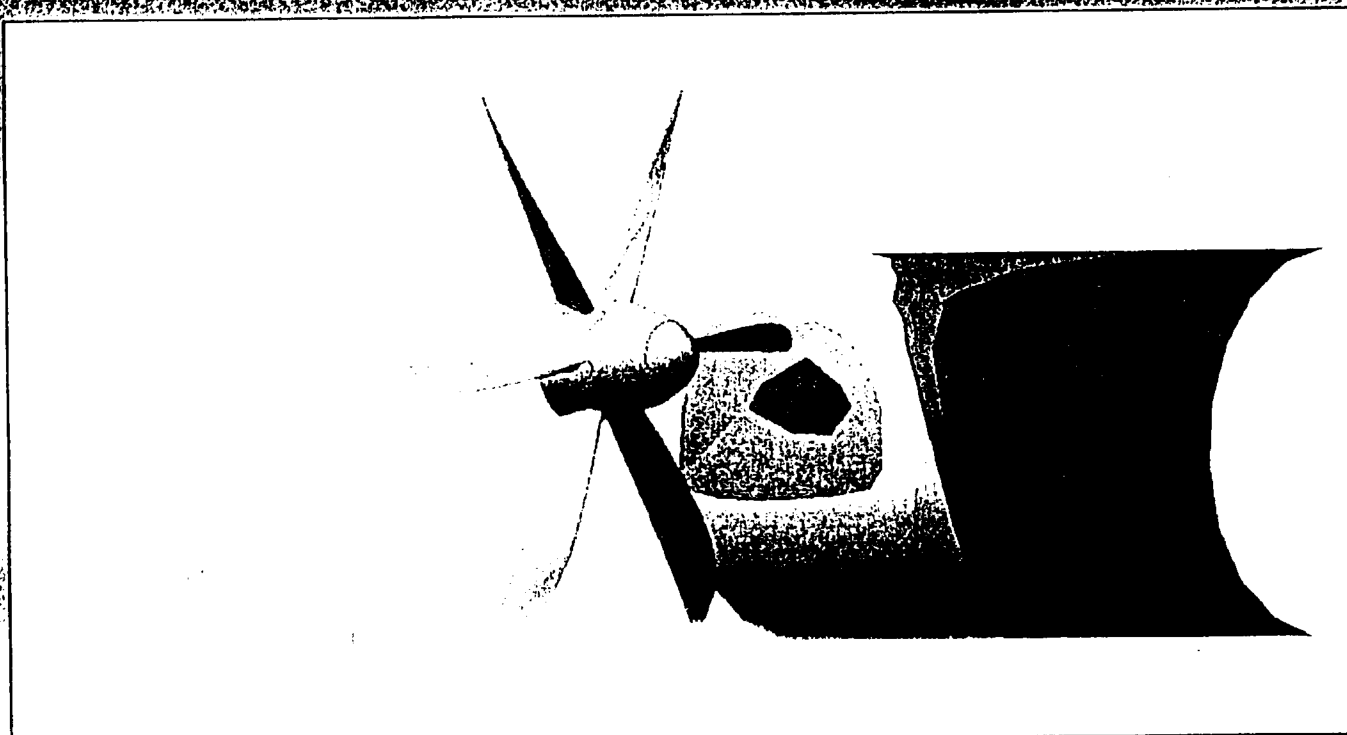
Economics @ 200 nm

	Dash 8/400 70 Seats Typical Regional	737-300 124-Seats Typical Mainline
Direct Operating Costs	1,368.17	3,224.10
General / Overhead	547.28	1,450.85
Total Operating Costs	1,915.43	4,675.95
Break - Even Seats	**21.8**	**53.1**
Profit (@ 45 Pax Load)	2,044.57	-715.95

52% Profit Margin

BOMBARDIER REGIONAL AIRCRAFT

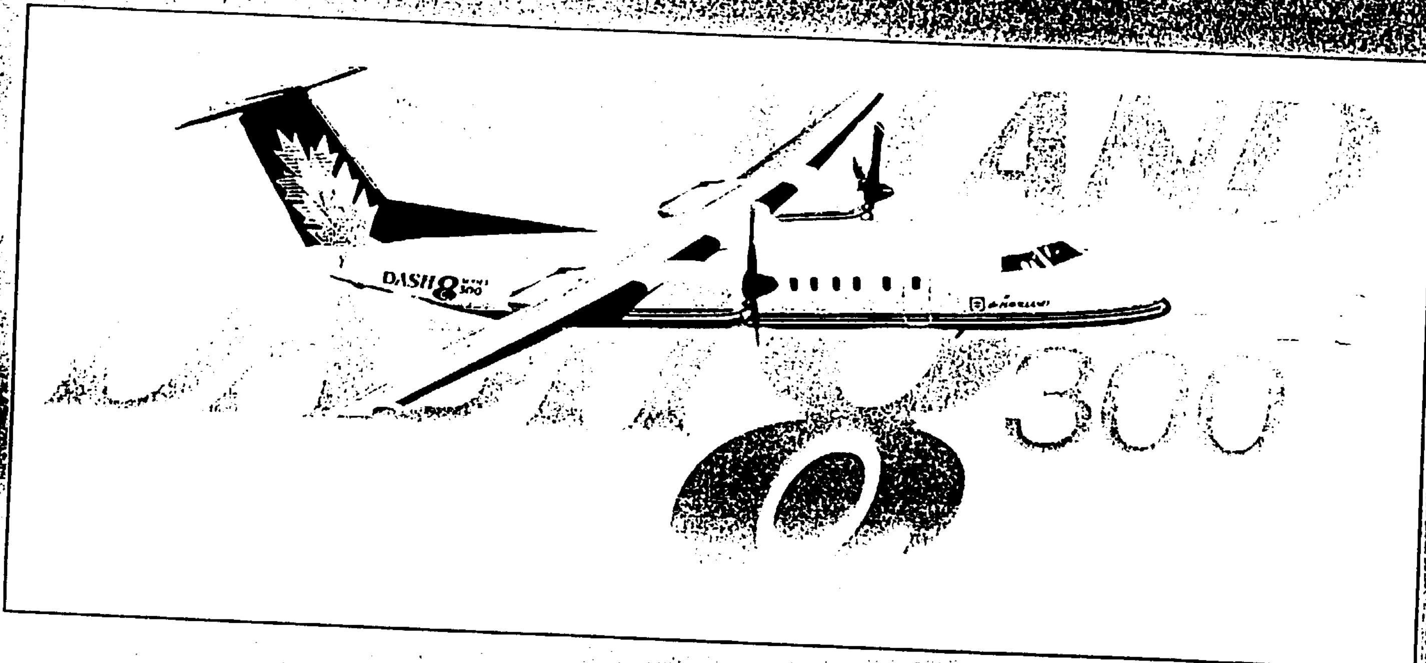
Turboprop Noise and Cabin Comfort



A Critical Issue Facing Turboprops

BOMBARDIER REGIONAL AIRCRAFT

Introducing The Dash 8Q



A Significant Advance In Noise And Vibration Suppression

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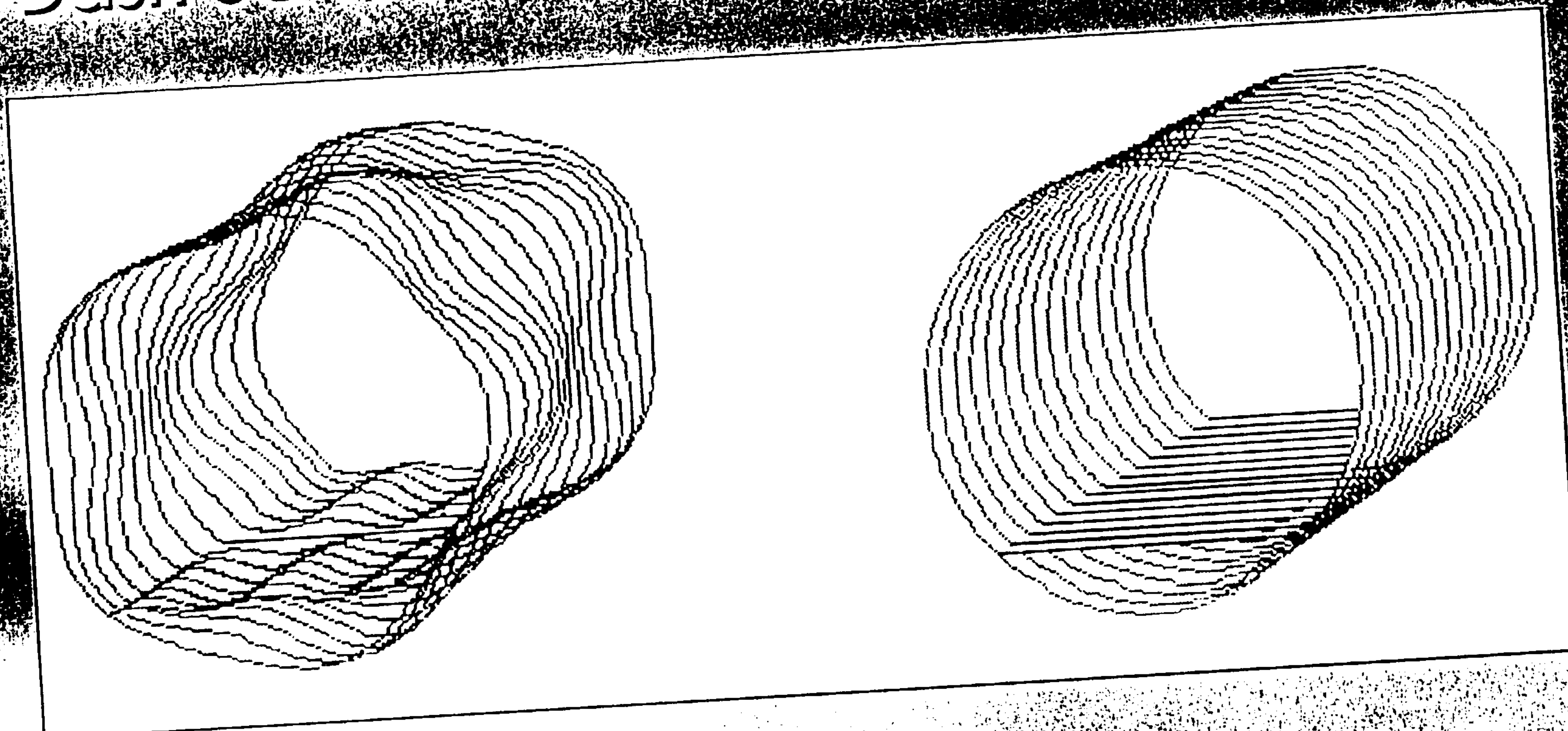
The Dash 8Q Technology



Computer Driven Noise and Vibration Suppression System

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Head-up Guidance System

Horizon Air Granted FAA Approval For Category II Low Visability Approaches At Category I Airports

ASC070.C9

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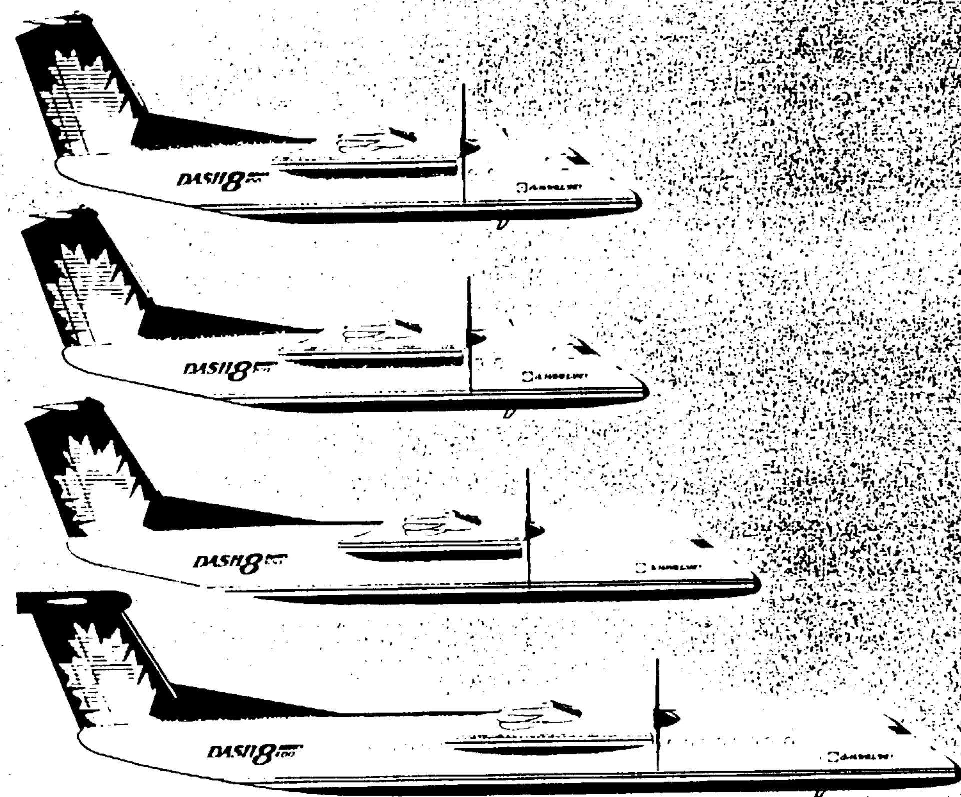
Dash 8 Family



Series 100
37 Seats
271 Knots (502 km/h)

Series 200
37 Seats
295 Knots (546 km/h)

Series 300
50 Seats
287 Knots (532 km/h)

Series 400
70 Seats
350 Knots (648 km/h)

Family Commonality for Increased Profitability

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31-849
p 11 5/27

Airline Quality Rating, Results 1997

By:

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Wichita State University

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For:

Conference on:
"Globalization and Continentalization of Air Transport Industry and related strategic, public policy, planning and operational problems and issues."

University of British Columbia
Vancouver, Canada
June 25-27, 1997

Air Transport Research Group
of the World Conference on Transport Research Society

AIRLINE QUALITY RATING, RESULTS 1997

Dean E. Headley, Wichita State University
Brent D. Bowen, University of Nebraska at Omaha

Abstract

The Airline Quality Rating (AQR) was developed and first announced in early 1991 as an objective method of comparing airline performance on combined multiple factors important to consumers. Development history and calculation details for the AQR rating system are detailed in The Airline Quality Rating 1991 issued in April, 1991, by the National Institute for Aviation Research at Wichita State University. This current report, Airline Quality Rating 1997, contains monthly Airline Quality Rating scores for 1996. Additional copies are available by contacting Wichita State University or University of Nebraska at Omaha.

The Airline Quality Rating 1997 is a summary of month-by-month quality ratings for the nine major domestic U.S. airlines operating during 1996. Using the Airline Quality Rating system and monthly performance data for each airline for the calendar year of 1996, individual and comparative ratings are reported. This research monograph contains a brief summary of the AQR methodology, detailed data and charts that track comparative quality for major domestic airlines through the 12 month period of 1996, and industry average results. Also, comparative Airline Quality Rating data for 1991 through 1995 are included to provide a longer term view of quality in the industry.

The Airline Quality Rating (AQR)

The majority of quality ratings available rely on subjective surveys of consumer opinion that are infrequently done. This subjective approach yields a quality rating that is essentially noncomparable from survey to survey for any specific airline. Timeliness of survey based results can be a problem as well in the fast changing airline industry. Before the Airline Quality Rating, there was effectively no consistent method for monitoring the quality of airlines on a timely, objective and comparable basis. With the introduction of the AQR, a multi-factor, weighted average approach became available. This approach had not been used before in the airline industry. The method relies on taking published, publicly available data that characterizes airline performance on critical quality factors important to consumers and combines them into a rating system. The final result is a rating for individual airlines with ratio scale properties that are comparable across airlines and across time.

The Airline Quality Rating (AQR) is a weighted average of 19 factors (see Table 1) that have importance to consumers when judging the quality of airline services. Factors included in the rating scale are taken from an initial list of over 80 factors. Factors were screened to meet two basic criteria; 1) a factor must be obtainable from published data sources for each airline; and

2) a factor must have relevance to consumer concerns regarding airline quality. Data used in calculating ratings represent performance aspects (i.e. safety, on-time performance, financial stability, lost baggage, denied boardings) of airlines that are important to consumers. Many of the factors used are part of the Air Travel Consumer Report maintained by the Department of Transportation.

Final factors and weights were established by surveying 65 airline industry experts regarding their opinion as to what consumers would rate as important (on a scale of 0 to 10) in judging airline quality. Also, each weight and factor were assigned a plus or minus sign to reflect the nature of impact for that factor on a consumer's perception of quality. For instance, the factor that includes on-time performance is included as a positive factor because it is reported in terms of on-time successes, suggesting that a higher number is favorable to consumers. The weight for this factor is high due to the importance most consumers place on this aspect of airline service. Conversely, the factor that includes accidents is included as a negative factor because it is reported in terms of accidents relative to the industry experience, suggesting that a higher number is unfavorable to consumers. Because safety is important to most consumers the weight for this factor is also high. Weights and positive/negative signs are independent of each other. Weights reflect importance of the factor in consumer decision making, while signs reflect the direction of impact that the factor should have on the consumer's rating of airline quality. When all factors, weights and impacts are combined for an airline and averaged, a single continuously scaled value is obtained. This value is comparable across airlines and across time periods.

The Airline Quality Rating methodology allows comparison of major domestic airlines on a regular basis (as often as monthly) using a standard set of quality factors. Unlike other consumer opinion approaches which rely on consumer surveys and subjective opinion, the AQR uses a mathematical formula that takes multiple weighted objective factors into account in arriving at a single rating for an airline. The rating scale is useful because it provides consumers and industry watchers a means for looking at comparative quality for each airline on a timely basis using objective, performance-based data.

Table 1

AIRLINE QUALITY RATING FACTORS, WEIGHTS AND IMPACT

	FACTOR	WEIGHT	IMPACT (+/-)
1	Average Age of Fleet	5.85	-
2	Number of Aircraft	4.54	+
3	On-Time	8.63	+
4	Load Factor	6.98	-
5	Pilot Deviations	8.03	-
6	Number of Accidents	8.38	-
7	Frequent Flier Awards	7.35	-
8	Flight Problems[a]	8.05	-
9	Denied Boardings[a]	8.03	-
10	Mishandled Baggage[a]	7.92	-
11	Fares[a]	7.60	-
12	Customer Service[a]	7.20	-
13	Refunds[a]	7.32	-
14	Ticketing/Boarding[a]	7.08	-
15	Advertising[a]	6.82	-
16	Credit[a]	5.94	-
17	Other[a]	7.34	-
18	Financial Stability	6.52	+
19	Average Seat-Mile Cost	4.49	-

[a]Data for these factors is drawn from consumer complaints as registered with the Department of Transportation and published monthly in the Air Travel Consumer Report.

The basic formula for calculating the AQR is:

$$AQR = \frac{- w_1F1 + w_2F2 + w_3F3 +/- \ldots w_{19}F19}{w_1 + w_2 + w_3 + \ldots w_{19}}$$

What the Airline Quality Rating Tells Us about 1996

Since the Airline Quality Rating is comparable across airlines and across time, monthly rating results can be examined both individually and collectively. The pages following these summary comments outline the AQR scores by airline, by month for 1996. For comparison purposes, results for each airline are also displayed for 1991 through 1995. A composite industry average chart that combines the nine airlines tracked is shown.

For the first time in the AQR's six year history, the scores show some clear groupings. Southwest is clearly at the top of the ratings. A second group of airlines, American, United, Delta, Continental, and Northwest, make up a very closely competitive group. It is reasonable to conclude that the small differences in AQR scores for this group suggests very little performance differences among the group. A third group, US Airways, America West, and Trans World, are clearly not performing at the same level as the other major airlines across all of the AQR factors.

The AQR results for 1996 indicate that:

- Southwest Airlines maintained the top rated position, with an improved 1996 average AQR score over 1995. While some of the other large carriers increased their AQR scores, Southwest had a commanding lead in 1996. They recorded the best annual average on-time percentage of the major carriers and were the only carrier to have an average on-time percentage over 80% for the year. Southwest had the second highest denied boardings rate and fewest lost bags of the major carriers.

- American Airlines slipped to a lower average AQR score in 1996, keeping them in the second rated position. Compared to 1995 their 1996 performance was weaker in on-time operations, mishandled more baggage, denied passenger boardings more frequently, and had a higher volume of consumer complaints.

- United Airlines maintained its third position in the 1996 ratings, even though their yearly average shows a decline in performance from 1995. As with many airlines, United had a lower on-time percentage for 1996, a higher rate of mishandled baggage, and a higher frequency of denied boardings. On the positive side, they had fewer consumer complaints for 1996. For the year, United was a relatively consistent quality performer, just at a slightly lower level than for 1995.

- Delta Airlines showed improved AQR scores from May, 1996 through December, 1996. Overall, the difference in Delta's average 1996 AQR score compared to their 1995 average score is very little, but positive. Their steady performance helped them maintain their position. Most noticeable were more negative outcomes in the areas of on-time performance, denied boardings, and consumer complaints.

- Continental Airlines showed dramatic gains again in 1996, with the most improvement in AQR scores of all rated airlines. Better performance with the fewest denied boardings, second highest on-time performance, second best lost baggage rate, and a nearly 50 percent reduction in consumer complaints made a very noticeable difference. The distance between Continental and other major carriers in 1996 was made up with consistently good performance in all areas rated. The AQR scores show that Continental Airlines is clearly the most improved airline of the major carriers again in 1996.

- Northwest Airlines made consistent performance level increases from February, 1996 through December, 1996. They registered the second largest gain in average AQR score of all the airlines. Like 1995, the current year saw a general increase in monthly scores. This increase did not effect their position, but brought them much closer to the performance levels of other airlines. Northwest tied with the second highest on-time performance in the industry. They improved their baggage handling, but increased the rate of denied boardings and number of consumer complaints.

- US Airways maintained an AQR score with months of gains and losses at about the same levels as in 1995. Looking at some of the details reveals that US Airways was only slightly worse in on-time performance and lost baggage and had about the same rates of denied boardings and consumer complaints.

- America West made a slight improvement in their AQR scores for 1996 until August, 1996. After August, problems with denied boardings really hurt their AQR scores. In a year of relative consistency, this translated into a move from fifth to eighth in overall position. America West had a lower on-time percentage, fewer lost bags, and a higher rate of complaints. A serious denied boardings problem in the fourth quarter took their AQR scores down overall.

- Trans World Airlines was a steady performer in 1996, generally finishing the year at the same AQR score levels as in 1995. TWA has the worst on-time percentage, the second worst baggage handling record, and the highest rate of consumer complaints of the major carriers.

- For 1996 the overall industry average AQR score improved over the 12 month tracking period. The AQR industry average score for 1996 is slightly better than for 1995, suggesting that performance has turned the corner along with the financial recovery the industry is experiencing.

Observations About the Industry and a Look at the Future

As measured by the Airline Quality Rating, quality generally increased during 1996 across the industry, although quality scores finished on a downward trend near the end of 1996. Overall quality had diminished annually as measured by the AQR for most of the previous years. This finding is consistent with more casual industry watching. As the quality of performance increases, we can note that improved stability is evident across the industry. By looking closely at AQR scores, we see evidence that individual air carrier performance is more stable in a majority of cases. Comparative performance among the major carriers is certainly a key finding of the AQR research methodology and helps demonstrate the very competitive environment of the industry.

Continued financial recovery was the hallmark of the airline industry in 1996. Most observers would agree that 1996 was a good year financially for the industry. Competition from new industry players is still a concern for the major airlines, as is the focus on safety and security issues.

Looking to a broader perspective, there are other issues which faced the industry in 1996. Global alliances in passenger and cargo services have become more apparent in our domestic market and our domestic airlines continue to seek global connections and alliances. This is evidenced by code sharing arrangements and our air carriers' support of liberalized bilateral agreements. The U.S. is capitalizing financially on the foreign carriers desire to fly to domestic destinations by charging fees for flyover privileges. These fees are generally being used to enhance our level of domestic air service.

Looking Ahead....

- ✈ Strong financial performance for the industry should continue. With moderate projected growth in passenger volume in both the near and long term future, and near double digit percentage increases in air fares; carriers are positioning themselves to reap profits and finance needed equipment updates. Some airlines may not find this time of prosperity as rewarding or opportunistic as others, but, the tide certainly has turned in favor of a more healthy industry.

- ✈ It is very evident that safety is a major concern throughout the industry. The recent Gore Commission report adds Presidential priority to maintaining a focus on safety and security issues at all levels of flight operations.

- ✈ Continued movement toward point-to-point service availability will be a hallmark change for the second half of the '90s. Consumers are demanding this type of service delivery. Increased competition from startups, more niche marketing, and new smaller economical jet aircraft will produce opportunities for route structures that force all airlines to be alert in identifying and meeting consumer demand to stay competitive.

- ✈ Stage 3 readiness (noise abatement) is fast approaching a deadline in the year 2000. While airlines are making good efforts to meet the requirements, as much as 30 percent of the domestic jet fleet still does not meet the federal guidelines. This should continue to affect the activity seen in the output of new aircraft manufacturing and related industries.

- Demand has influenced pricing increases. Continued cost cutting by the airlines will be attempted, but the outcome will be affected by taxes and user fees imposed. While these types of added costs are seen as necessary to fund certain changes, they certainly affect consumers total costs to fly, and that ultimately influences the volume of travelers using commercial air services.

- A potential labor dispute at Amtrak could affect the airline business. If trains are not a travel option, many travelers will seek the airlines as a preferred travel mode, producing increased demand at a time when the system is usually operating with seasonally high loads. This could have both good and bad outcomes for the consumer and carriers.

- Issues surrounding frequent flyer programs and rules will continue to be a source of unrest for consumers. Changes by the airlines and uncertainty about the tax status of the accumulated "miles" will keep the issue heated for both consumers (particularly business travelers) and the airlines.

- Air traffic control modernization is moving ahead slowly. With safety and air traffic access issues at the forefront of both consumer and government concerns, the updating of the system should move along more rapidly. The Department of Transportation (DOT) and Federal Aviation Administration (FAA) must find a way to resolve the responsibility and funding issues. This is a critical element in keeping the sky safe.

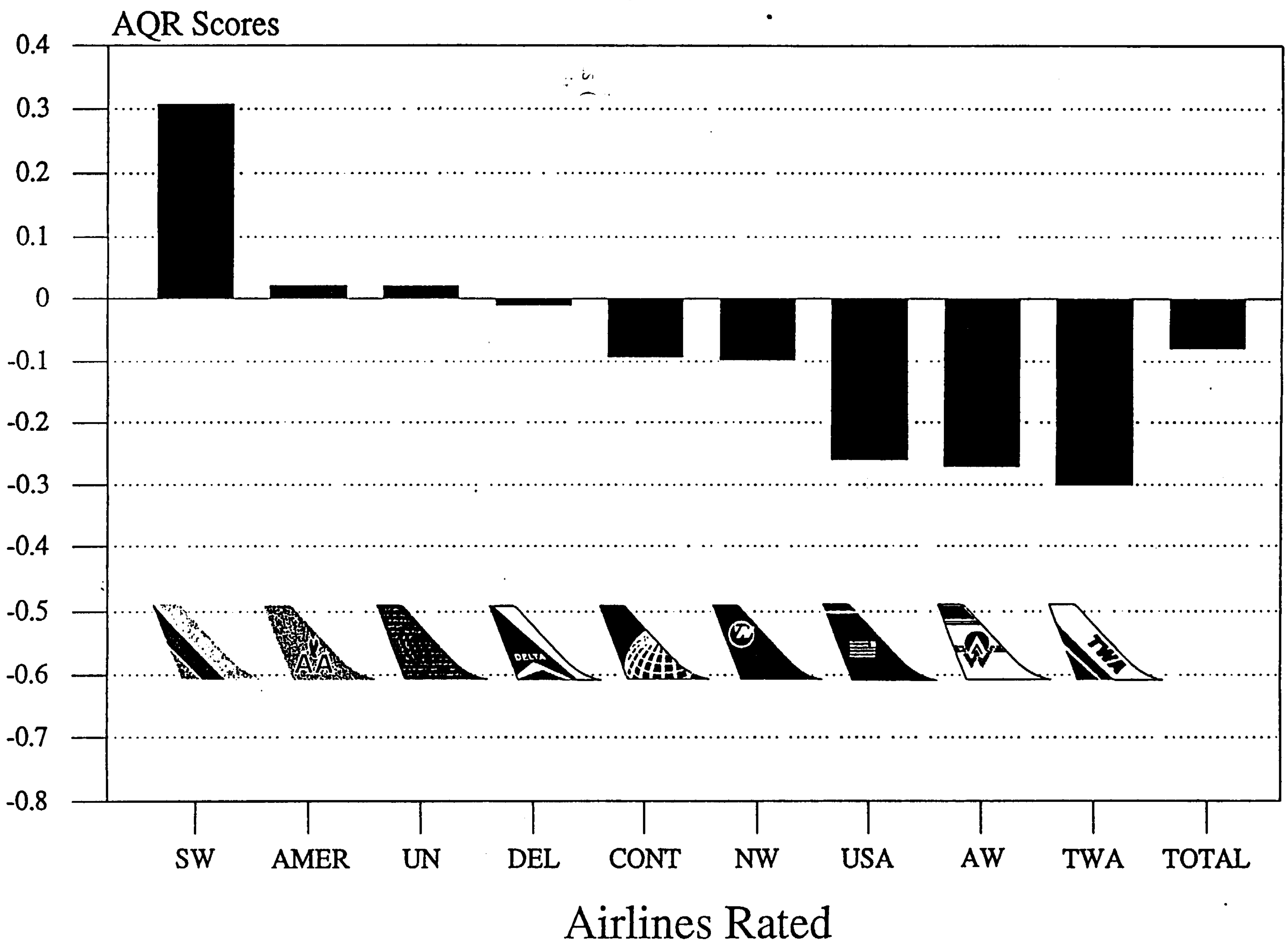
- Potential for a stable and prosperous period seems high. Long term labor agreements have been reached with many airline employee groups, the economy appears healthy, demand for air travel is strong, and supply is readily available in a variety of combinations. Labor driven disruptions are always a possibility, but recent actions by President Clinton may be an indication of how future disputes could be addressed.

- Free-flight (the ability to fly with most direct routing) must be put into effect. This new approach to commercial aviation routing will save the airlines a tremendous amount of money and will save the flying public substantial time in their travels. This type of routing should encourage the development of point-to-point route structures more readily.

- Revival of the Essential Air Services program under the DOT will create new opportunities for connecting rural areas to regional carriers. With the implementation of the Rural Air Service Survival Act in 1998, fees charged to foreign airlines overflying the U.S. will generate an expected $50 million annually that will be used to subsidize and improve rural air service and routes.

AIRLINE QUALITY RATING

MEAN AQR SCORES – 1996



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Collectively, Dr. Bowen's and Dr. Headley's research on the Airline Quality Rating (AQR) has met with widespread acceptance and acknowledgment. The Airline Quality Rating has been featured on *ABC's Good Morning America, The Cable News Network, The Today Show,* on network news, in *USA Today,* in *Aviation Week and Space Technology,* and in numerous other national and international media. Bowen and Headley have served as invited expert witnesses before the U.S. House of Representatives Committee on Government Operations and have served on multiple occasions as invited speakers and panelists for such groups as the National Academy of Sciences/Transportation Research Board. Resulting from work with the Airline Quality Rating, Bowen and Headley have been recognized with awards from the American Marketing Association, the American Institute of Aeronautics and Astronautics, Embry-Riddle Aeronautical University, the Travel and Transportation Research Association, W. Frank Barton School of Business, and others. The AQR research has been published in the Journal of Aviation/Aerospace Education and Research, Advances in Marketing, Business Research Methods, as well as other journals, proceedings, text books, and research monographs.

Productivity and Price Trends in the World's Major Airlines 1986-1995.

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Abstract

This paper tracks indices of prices received for airline outputs relative to the prices paid for inputs (labelled "total price productivity" TPP) in comparison with trends in total factor productivity TFP (ratio of output and input quantity indices). Comparing TFP and TPP reveals the sharing of productivity gains between a company and its customers, and hence the change in the firms financial performance.

Data are updated from Oum and Yu (1995). Data are for 22 of the world's major air carriers. The output quantity index incorporates five output categories: revenue passenger kilometres from scheduled services, freight tonne-kilometres, non-scheduled passenger and freight services, mail service, and incidental revenues. There are five input categories: labour, fuel, flight equipment, ground property and equipment, and "materials and other inputs." The input and output price indices are dual to the respective input and output quantity indices: total revenues from all services divided by the output index provides the output price index; total costs (including full costs of capital) divided by the input quantity index produces in input price index.

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1. INTRODUCTION

This study tracks the link between productivity gains and changes in the financial performance of the world's major airlines over the period 1986-1995. There is reason to expect some correlation between productivity and financial performance, but the relationship is not exact. Stated simply, productivity compares *quantities* of outputs relative to *quantities* of inputs. Financial performance depends on the *revenues* from outputs compared to the *expenditures* on inputs. A firm can be very efficient in terms of outputs per input, but it could be highly unprofitable if the revenues received are low compared to what it pays for inputs. Conversely, a firm with market power might be inefficient in input use but compensate financially by high prices. Nonetheless, it is possible to establish a direct link between productivity changes and financial performance. This is shown in part 2.

Part 3 describes the data on international airlines. Part 4 compares productivity trends with changes in financial performance. By monitoring productivity and input/output price ratios over time, this reveals how productivity gains are shared between the company and the customer and thus changing the firm's revenue/cost relationship. The patterns are compared and contrasted for the 22 major airlines. The conclusion in part 5 summarizes the usefulness of making these price/productivity comparisons and what it reveals about the airline industry generally and differences among specific carriers.

2.O PRODUCTIVITY, PRICES AND FINANCIAL PERFORMANCE

Productivity compares outputs with inputs, more specifically, the change in outputs compared with the change in inputs. One can compare one or more output categories with one or more input categories. However, such partial measures of productivity, although popular, are often misleading because they do not allow for other changes in outputs and inputs. For this reason economists advocate comprehensive productivity measures, called multi-factor productivity (MNP) or total factor productivity (TFP). The index number approach to TFP measurement compares the growth rate of a quantity index of all outputs with the growth rate of an input quantity index.[1]

As noted in the introduction, productivity and financial performance do not necessarily move together. However, they are linked by examining changes in prices received for outputs and prices paid for inputs along with the productivity changes. To illustrate the links, use some simple algebra for two time periods, 0 and 1. One can think of a single product firm employing only one input, or index numbers to represent multiple output and input prices and quantities. Note that for index numbers, the respective price and quantity indices must be dual to one another so that there is computational consistency.[2]

P_0 and P_1 are output prices (indexes);

Y_0 and Y_1 are output quantities (indexes);

W_0 and W_1 are input price indexes;

X_0 and X_1 are input quantity indexes;

hence

R revenue $= P \times Y$

C costs $= W \times X$

Costs include capital costs, i.e., these are total economic costs.

π_0 and π_1 are measure of economic profit; for analytical convenience defined as the ratio of revenues to costs rather than the difference.

$\pi_0 = R_0 / C_0$

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[1] An alternative approach to TFP measurement is to measure the shift in an econometric production or cost function. The interpretation of TFP is not identical in the two approaches (see Oum, Tretheway and Waters, 1992, for an explanation, or Diewert, 1992 for a more rigorous exposition). Because we wish to make comparisons of prices with quantity changes, it is appropriate to use the index number approach to TFP measurement.

[2] The price and quantity indices must satisfy the "product test," i.e., the ratio of price indices over two periods times the ratio of quantity indices should equal the ratio of corresponding expenditure indices.

Note that there is no requirement that economic profits be zero.

Total factor productivity (TFP) is measured by the growth of output relative to the growth in inputs:[3]

$$\text{TFP} = \frac{Y_1/Y_0}{X_1/X_0} \text{ or } \frac{Y_1/X_1}{Y_0/X_0} \tag{1}$$

(The second expression is the ratio of a TFP index for each period).

It is desirable to link productivity measurement with financial performance. This is straight-forward, but note that because TFP data includes capital inputs and their service price in calculating productivity, it is economic and not accounting profits which are to be compared with TFP. As noted, for analytical convenience, we work with economic profit n as a ratio of revenues to costs rather than the difference.

Any change in profitability between the periods is indicated by the change in revenue/cost ratios:

$$\pi_1/\pi_0 = \frac{R_1/C_1}{R_0/C_0} \text{ or } \frac{P_1Y_1 \,/\, W_1X_1}{P_0Y_0 \,/\, W_0X_0} \tag{2}$$

which is rewritten:

$$\pi_1/\pi_0 = \underbrace{\frac{Y_1}{Y_0} \times \frac{1}{X_1/X_0}}_{\text{TFP}} \times \underbrace{\frac{P_1}{P_0} \times \frac{1}{W_1/W_0}}_{1/\text{TPP}} \tag{3}$$

Any change in the financial condition of the firm/industry (economic profit) reflects the change in productivity <u>and</u> any change in relative prices of inputs and outputs. The first half of the right

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[3] For simplicity, the index is written is simple ratio form. For calculations we use the Tornqvist or translog form of an index number, which would take the natural log of these expressions rather than leave them in arithmetic form.

hand side of (3) is TFP. The second half is the growth in output prices relative to the growth in input prices. More in keeping with the economics literature on productivity, the right half of expression (3) is the reciprocal of what we label "total price productivity" or "total price performance" (TPP), the ratio of input prices to output prices.[4] By tracking TPP along with TFP, we can directly monitor any change in the firm's financial status along with its productivity changes.

Note that financial performance is monitored relative to the base period. If R_0/C_0 is not equal to unity, then the firm is not in long run competitive equilibrium. If $R < C$ and the firm is making a loss, it is necessary/desirable that the financial condition improve. It would be quite different if the firm started in a substantial monopoly position. Here public policy would be looking for a decline in the financial position. In brief, one must pay attention to the conditions in the base period R_0/C_0 in assessing the desired link between productivity and financial changes in the firm.

If competitive conditions do prevail, the firm is a price taker for both outputs and inputs and economic profits are zero hence $R/C = 1$ and TFP = TPP, i.e., all productivity gains (Y/X) are passed on in the form of lower prices for outputs relative to prices paid for inputs. In fact what we call TPP is occasionally used as a measure of TFP because they should be identical under competitive conditions.

One need not assume perfectly competitive conditions; the same relationship holds if there is no change in the market power position of the firm. If competitive conditions change, equation (3) is all the more interesting and useful because we can monitor changes from the initial market power position. For example, suppose a firm is gaining increased market power. It will not pass all productivity gains on to customers, and this will be shown by tracking TFP relative to TPP. If TFP is greater than TPP, the firm has retained part of the productivity gains as increased revenues rather than pass the full productivity gains through to its customers. *In particular, the ratio of TPP to TFP indicates the extent to which productivity gains are shared with customers.*

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[4] The change in input prices relative to output prices which we label TPP has been recognized for some time in the productivity literature (but not known by this name). The ratio of an input price index to an output price index is dual to the ratio of an output quantity index to an input quantity index (noted by Jorgenson and Griliches, 1967 citing earlier papers by Siegel, 1952 and 1961), but it is rarely calculated or examined. TPP has been used as an alternate measure of TFP in telecommunications where output measures were hard to obtain (e.g., Chessler 1988). The reciprocal of TPP (i.e., output price index over an input price index) can be thought of as a "terms of trade" concept for a firm.

In what follows, we compare TFP with TPP to indicate the extent of productivity gains, how these are shared between companies and their customers, and hence how the financial condition of the firm changes with productivity gains.

3.0 INTERNATIONAL AIRLINE DATA

The data for this study are described in Oum and Yu's (1995) study of productivity comparisons among airlines. Only a brief summary is provided here.

The data are a careful and systematic compilation of data on major world airlines, limited to those for which all data categories could be obtained in like fashion. The time period covers 1986 through 1995; 22 airlines are included (one airline, Cathay Pacific, has data only from 1988).

Five categories of output are compiled: (1) revenue passenger kilometres (RPK) of scheduled air service; (2) revenue tonne kilometres (RTK) of scheduled freight service; (3) mail service (measured in RTK); (4) non-scheduled (charter) passenger and freight services, measured as RTK; and incidental services (measured in revenues and deflated by the GDP deflator for the home country; see Oum and Yu, 1992, pp.183-4 for details). The incidental services include a wide variety of services including catering, services supplied to other airlines, and consulting services. The airlines differ substantially in the importance of different output categories. The output index is constructed using revenue shares as weights. The Tornqvist or translog index formula is used.

There are five categories of inputs: (1) labour measured as number of employees; (2) fuel measured in gallons; (3) flight equipment capital is measured by an index incorporating different aircraft types; (4) ground property and equipment capital constructed using the Christensen-Jorgenson (1969) perpetual inventory method (see Oum and Yu, 1995, p.184); and (5) "materials and other" which is a residual or "catch-all" category for all other expenditures by the airline companies. The materials and other category is estimated by subtracting labour, fuel and capital input costs from ICAO's reported total operating costs. Deflating the residual expenditures by an input price index produces and input quantity index for this category.

The output and input categories are combined into multilateral indexes following the procedures recommended by Caves, Christensen and Diewert (1982). Multilateral indices enable one to compare both absolute productivity differences across firms as well as growth rates over time. The quantity indices are normalized around a particular carrier and year, specifically American Airlines in 1990. That is, the output quantity index and input quantity index are both set at unity for American Airlines in 1990, and all output, input and TFP indices are expressed relative to this base.

Oum and Yu (1995) calculated the total economic cost for each airline, i.e., including a capital service price for capital inputs. For this study, dividing the total economic costs by the input quantity index produces the dual input price index. Similarly, dividing total revenues for each airline by its output quantity index produces the dual output price index. Note that the output and input price indices for the base year and carrier will not equal unity unless revenues and total economic costs are equal in that year. This is the long run expectation in a perfectly competitive industry, but a revenue/cost (R/C) ratio of exactly unity will be rare. In the case of American Airlines in 1990 (i.e., the base for productivity comparisons), the R/C is 1.082 hence the ratio of input to output price indices (TPP) for that year and carrier is also 1.082. The first year (1986) ratio of input to output price indices (TPP) for any airline is determined by the R/C for that airline in that year and the TFP index (which is relative to the American Airlines' base). To illustrate further:

O = output quantity index
I = input quantity index
R = total revenues
C = total economic costs

Then:

$$TFP = O / I$$

$$TPP = (C/I) / (R/O)$$

or

$$TPP = [1 / R/C]\ TFP \tag{4}$$

Given TFP, if R > C in that year then TPP > TFP; if R/C were unity in 1986, TPP would equal TFP in that year. Expression (4) applies to subsequent years as well. Divergence between TFP and TPP from one year to another will determine the change in R/C. If ΔTFP > ΔTPP, then R/C improves because the firm has been able to retain part of the productivity gain ΔTFP. Conversely, if a firm faces rising input prices and is unable to offset this by productivity gains, then ΔTPP > ΔTFP and the firm deteriorates financially.

Note the interpretation of this "total" price. Just as the output quantity index reflects the combination of all outputs (weighted by their relative importance as indicated by revenue shares), the dual output price index represents the combined effect on the firm's output prices taking the multiple outputs into account. More typically, most discussion of airline price trends focus only on passenger yields. The total price index is a more comprehensive measure of price.

4.0 PRODUCTIVITY AND PRICE TRENDS

Figures 1 through 22 plot the two productivity measures for each airline, for 1986 through 1995. The TFP figures are "raw" or "gross" productivity measures. They do not adjust for operating characteristics which make some airlines inherently more or less efficient. For example, a carrier serving high density long haul routes will appear highly productive in terms of outputs to inputs. Conversely, a carrier serving lower density shorter haul traffic will require more inputs per RPK. Oum and Yu (1995) "decompose" the TFP values to distinguish productivity differences which may be attributed to managerial efficiency rather than to endogenous influences on productive efficiency. For this present study, the source of productivity differences is not important; our interest is in the relationship between productivity and price changes, and for this sources of productivity do not matter. The graphs reveal the productivity changes (TFP) and how prices paid for inputs compare with the prices received for outputs, i.e., the extent to which productivity gains are passed through to customers (TPP). TFP and TPP together will show the revenue to economic cost ratio and how it changes over time. For this reason, revenue/economic cost is not plotted in most figures. It is included for one airline (Qantas) in Figure 1 as an illustration.

The airlines are grouped as follows:

Qantas is listed by itself.

UK/Europe

- British Airways
- Air France
- Iberian
- KLM
- Lufthansa
- SAS
- Swiss Air

North American carriers

- American
- Continental
- Delta
- Northwest
- United
- US Air
- Air Canada

Canadian

Asian carriers

All Nippon (ANA)

Japan Airlines (JAL)

Korean (KAL)

Cathay Pacific

Singapore (SIA)

Thai Airlines

The relationship between productivity, total price changes and financial performance are shown in Figure 1 for Qantas. The choice of carrier is arbitrary for this illustration. This figure is described in some detail; the reader can interpret most of the remaining figures. In Figure 1, the initial (1986) TFP index value is 0.88, indicating a productivity level just under 90 percent of the productivity level of American Airlines in 1990 (the base of the multilateral index series). The revenue/cost ratio was calculated to .90 (approximately). As a result, TPP for that first year is .98 indicating that the prices paid for inputs are almost the same as the prices received for outputs (remember that these price indexes are dual to the output and input quantity indexes). These three points for 1986 can be seen in Figure 1.

In 1987, Qantas shows a modest productivity gain (greater output relative to input quantities), and a decline in the prices paid for inputs relative to prices received for the outputs. The result is a sharp improvement in the ratio of revenues to total economic costs (about 1.10). The next two years show modest productivity gains and slightly faster growth in the input/output price ratio; the result is the revenue/cost ratio remains greater than one but declining.

1990 shows a decline in productivity and a sharp rise in prices paid to inputs relative to prices received for outputs. This results in a sharp fall in the revenue/cost ratio (to 0.78). The next three years show increased productivity, which exceeds the input/output price ratio, hence revenue/costs recover. Productivity dips in 1994 but so did the input/output price ratio hence revenue/costs changed little. 1995 saw a rise in productivity with constant prices paid for inputs relative to outputs, hence revenue/costs rise.

TFP and TPP are plotted for British Airways (BA) and European air carriers in Figures 2 through 8. For most of these carriers, TFP and TPP track fairly closely, indicating that productivity gains are reflected in output price reductions relative to the prices paid for inputs. For BA, TFP and TPP track particularly close together which is indicative of a fairly competitive market structure overall facing BA. Looking over the whole period, BA's TFP index starts off low relative to the American Airlines' (AA) base (0.64) but rises noticeably to

0.86. TPP tracks TFP closely indicating that these productivity gains have largely been passed through to customers by output prices not rising with input prices, except for 1995 where a portion (about half) are not passed through but retained as revenues in that year.

TFP and TPP track closely for Lufthansa and SAS. KLM and Swissair show TFP growing faster than TPP after 1991 indicating that some of the productivity gains have been retained by these firms. An apparent data anomaly disrupts the trend for Air France. Iberian airlines has seen little productivity growth but there has been pressure on its input/output price ratio hence its economic condition will have deteriorated.

Figures 9 through 14 show the major American carriers and Figures 15 and 16 show Air Canada and Canadian Airlines, respectively. The data for most of the carriers suggest a highly competitive industry: TFP and TPP track closely together, and for some of the carriers TPP is greater than TFP indicating weakening financial condition because pressures on prices are not being offset by sufficient productivity gains. American Airlines is the base or reference carrier for the productivity index, hence TFP equals unity for 1990. Its TPP equals 1.08 in that year because the revenue/cost ratio equals 0.924 in 1990. For 1990 through 1992 TPP exceeds TFP indicating deteriorating financial condition.

Despite starting out as a relatively high productivity carrier, Continental's TFP declined until 1990 before rebounding part way. But its TPP is consistently higher indicating that the carrier has been unable to obtain prices for its outputs which kept pace with the prices paid for inputs. Hence its financial condition has steadily worsened until 1995. It is less extreme, but since 1988 US Air also has seen productivity growth not sufficient to offset the rising prices of inputs relative to the prices received for outputs.

Both of the Canadian carriers show signs of financial deterioration over the full period as productivity growth has been modest but there has been sharp pressure on prices, i.e., output prices not keeping pace with rising input prices and productivity gains were not sufficient to offset this. Canadian airlines' productivity improves noticeably after 1992 but again the productivity gains appear to have been largely passed through as price reductions (or limited price increases) to customers.

For the most part, the Asian carries (Figures 17 through 22) show a different pattern. The absolute productivity level varies considerably across the carriers, and only two carriers (Korean and Thai) show noticeable improvement in productivity. But several of them show high financial performance, i.e., an ability to obtain prices for outputs which are not offset by rising prices of inputs. The gap between TPP and TFP declines over time for ANA and JAL (Figures

17 and 18, respectively) suggesting rising competition over the period. Korean Air (Figure 19) shows noticeable productivity improvements with most of the productivity gains (but not all) passed through to customers. Cathay, Singapore and Thai (Figures 20, 21 and 22, respectively) have been able to sustain TFP greater than TPP throughout the period, i.e., they have maintained strong financial performance regardless of their productivity performance. For Thai however, it has shown substantial productivity growth (but from a low base) and a substantial portion of these gains (about two-thirds) has been passed through as lower prices for outputs relative to prices paid for inputs.

5.0 Conclusion

This paper compares productivity trends of the world airlines with how they manifest themselves in changes in output prices charged relative to input prices paid. That is, have productivity gains been passed on to customers or retained by the respective airlines thereby improving their financial condition? The analysis is done by constructing the dual input and output price indices which correspond to the input and output quantity indices used to calculate total factor productivity (TFP). This price ratio is labelled "total price productivity" or "total price performance" (TPP) reflecting the fact that these price indices take all output and input categories into account as do the TFP quantity indices. In competitive industries, one expects the growth of input prices relative to output prices to equal productivity gains, i.e., productivity enables the firm to raise output prices by less than the rise in input prices, and competition will force the full productivity gains to be passed on to customers.

Data are for 22 major airlines in the world for 1986 through 1995.

The data show both similarities and differences across the carriers. Absolute productivity levels as well as rates of growth differ substantially. Nearly all carriers show at least some productivity gains and, in most cases, most of the productivity gains were passed on to customers as indicated by TPP tracking close to TFP. For several carriers TPP exceeds TFP, i.e., input prices have risen faster than output prices and productivity was not sufficient to offset this, hence these airlines' financial condition has deteriorated. For the most part, the Asian carriers have been able to retain some of the productivity gains as improved financial performance, whereas North American and European carriers have been less successful. That is to say, the data suggest greater competitive forces at work in these other markets. This is particularly so for North America where over the sample period every carrier shows input prices paid exceeding the output prices obtained and these price differences are not offset by sufficient productivity gains. This pattern is changed only for two carriers and for the most recent years. That is, the financial condition of North American carriers has deteriorated despite what productivity gains they have been able to achieve. The European story is in between: TFP and TPP track fairly close together but some carriers have been able to retain at least some of the productivity gains to improve their financial condition, notably KLM and Swissair.

It should be noted that the data to make this comparison of prices and productivity sharing are implicit in the data already compiled to make productivity comparisons. But researchers have not been making use of the duality relationship between productivity and price changes. Apart from the specific results for airlines, this paper shows how existing data for total factor productivity measurement can be used to also reveal productivity sharing and the changes in overall financial performance.

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Figure 1: Qantas
(TFP, TPP & Rev/Cost Indices)

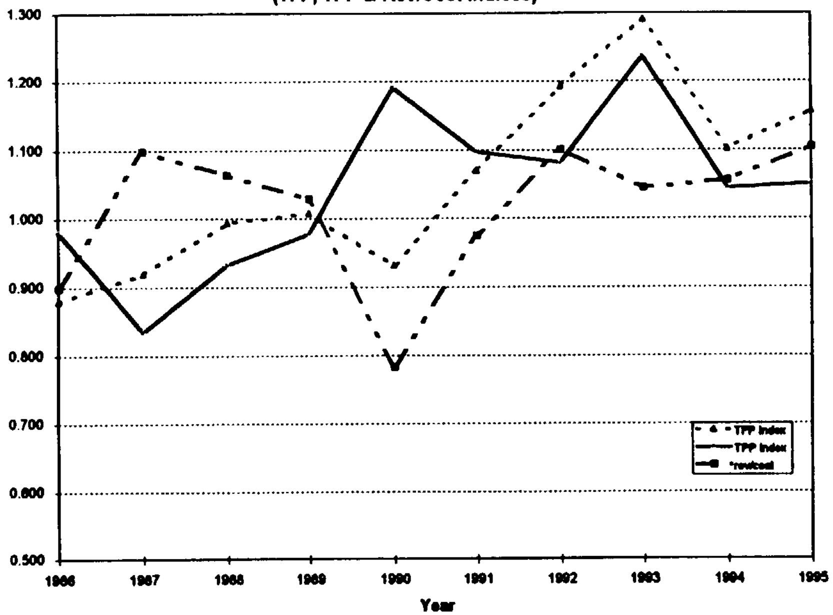


Figure 2: British Airways
(TFP & TPP Indices)

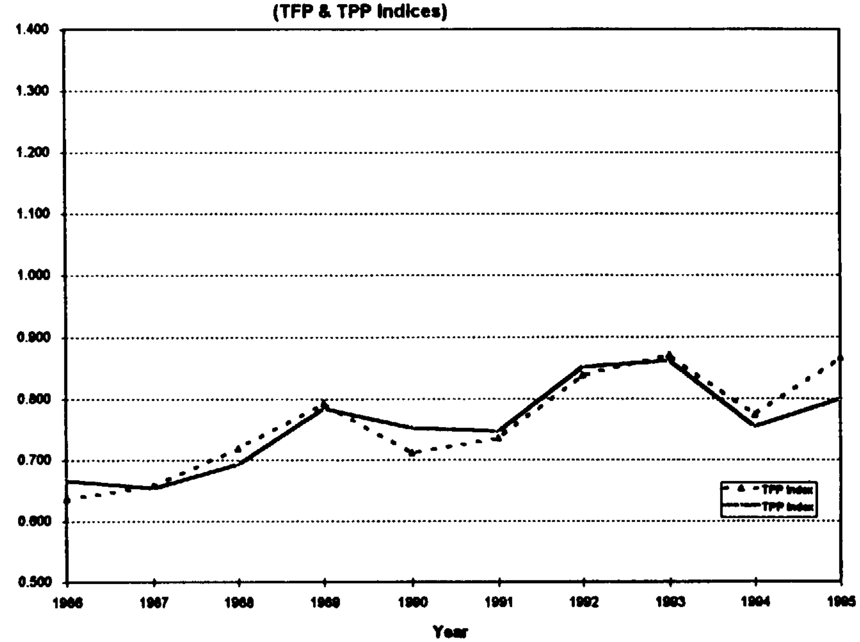


Figure 3: Air France
(TFP & TPP)

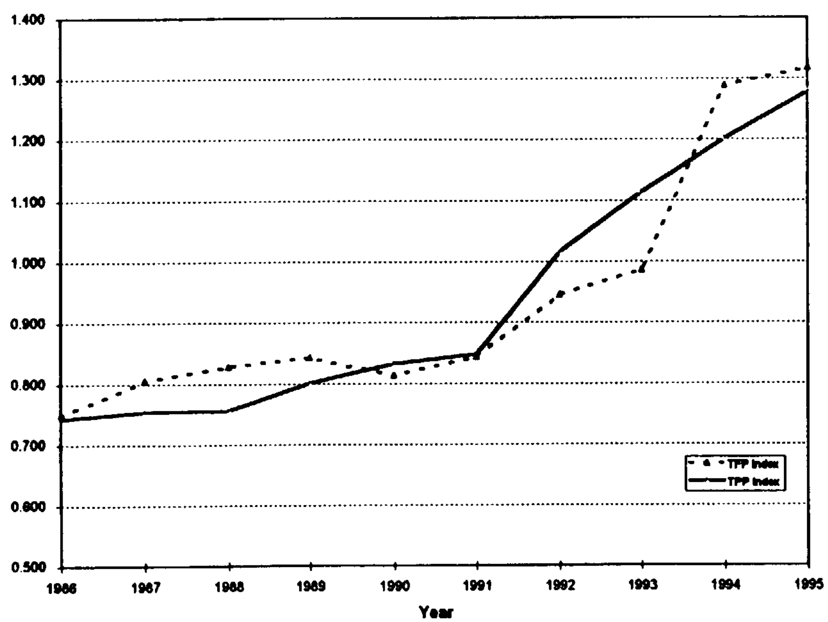


Figure 4: Iberia
(TFP & TPP)

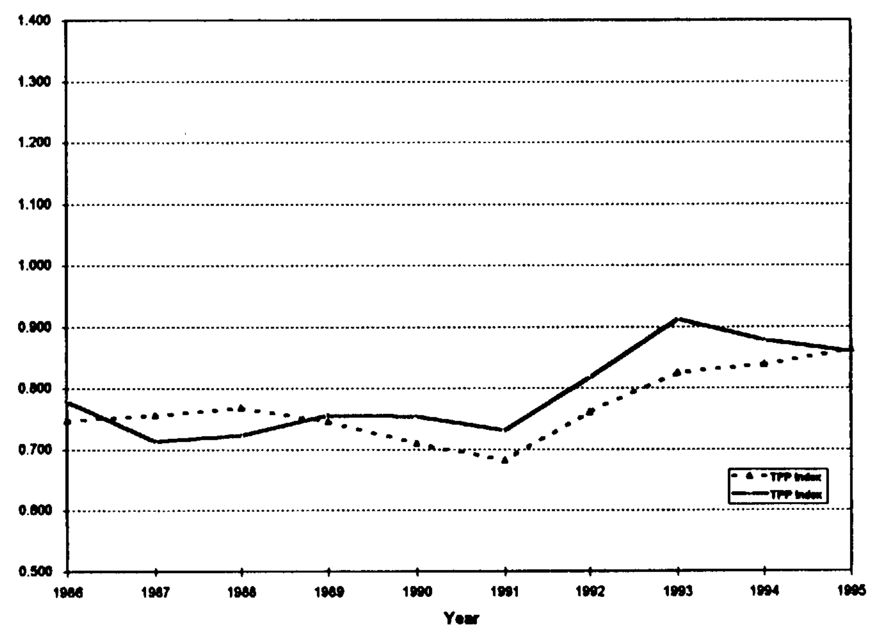


Figure 5: KLM
(TFP & TPP Indices)

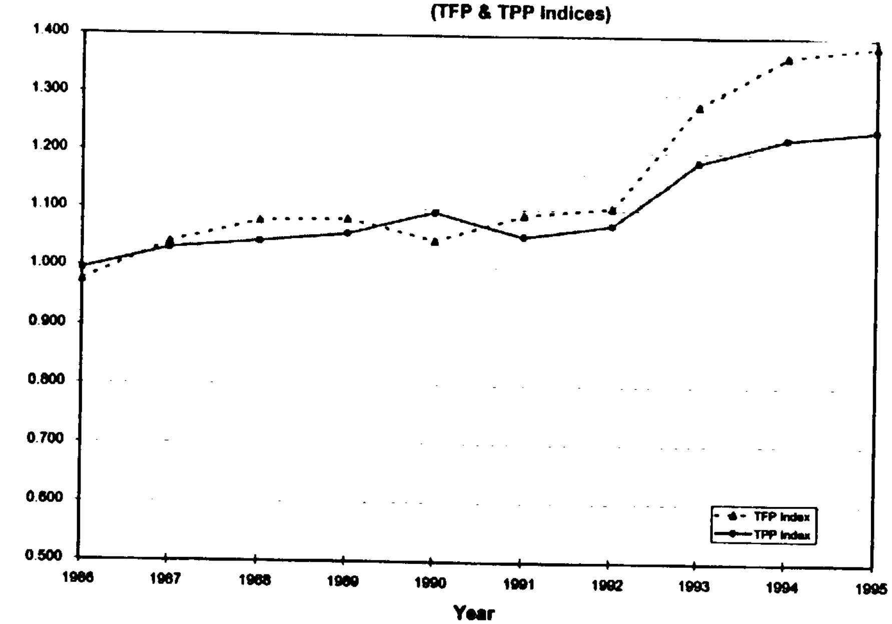


Figure 6: Lufthansa
(TFP & TPP Indices)

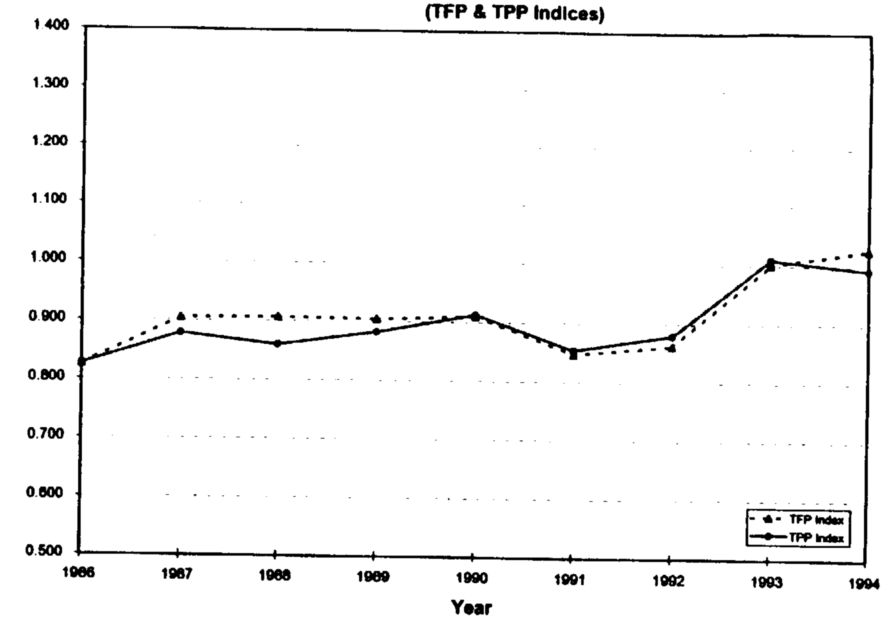


Figure 7: SAS
(TFP & TPP Indices)

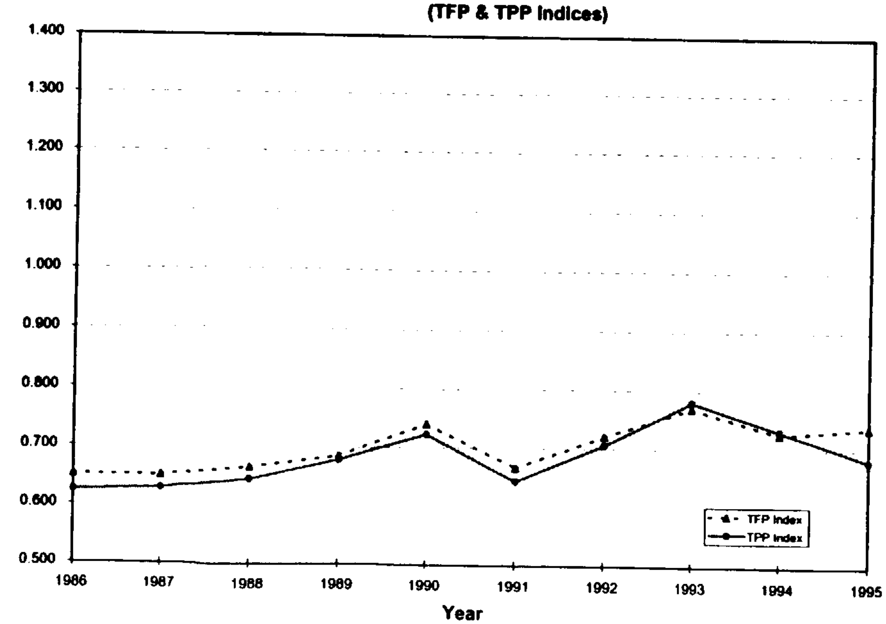


Figure 8: Swiss Air
(TFP & TPP Indices)

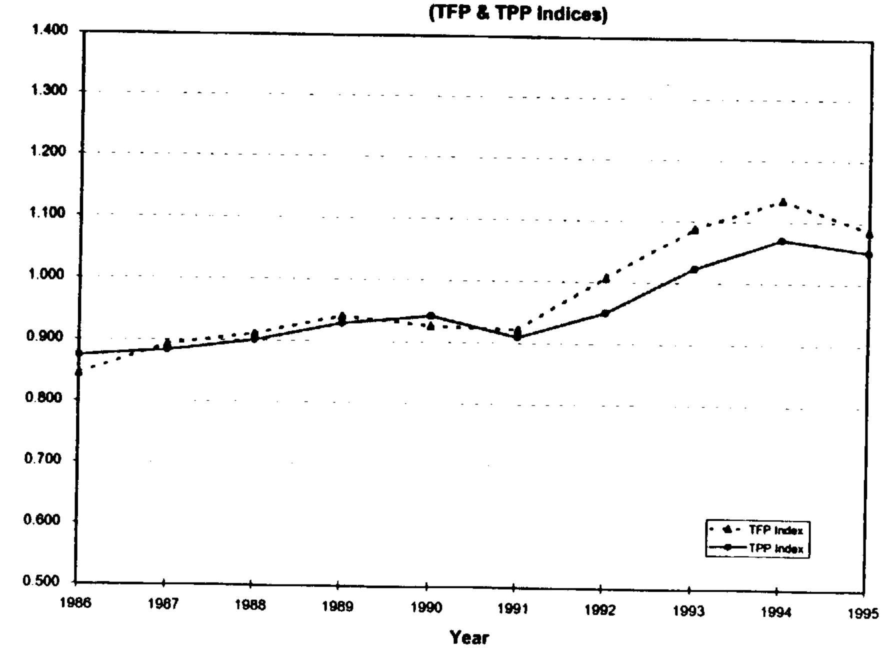


Figure 9: American Airlines
(TFP & TPP Indices)

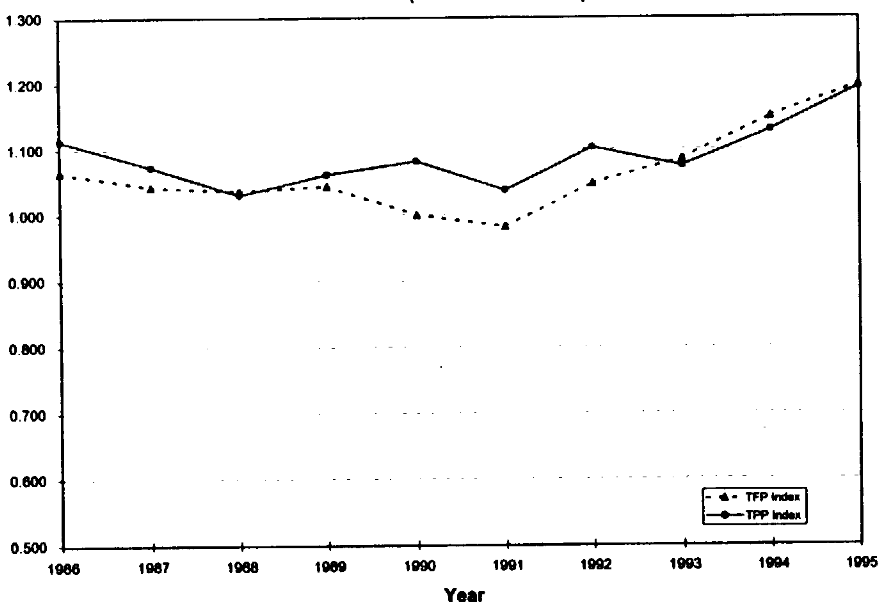


Figure 10: Continental Airlines
(TFP & TPP Indices)

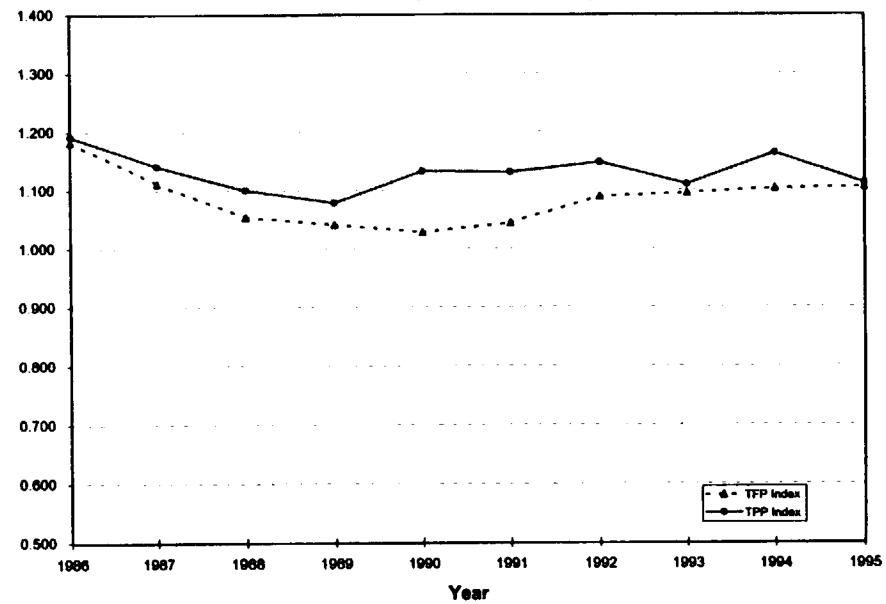


Figure 11: Delta Airlines
(TFP & TPP Indices)

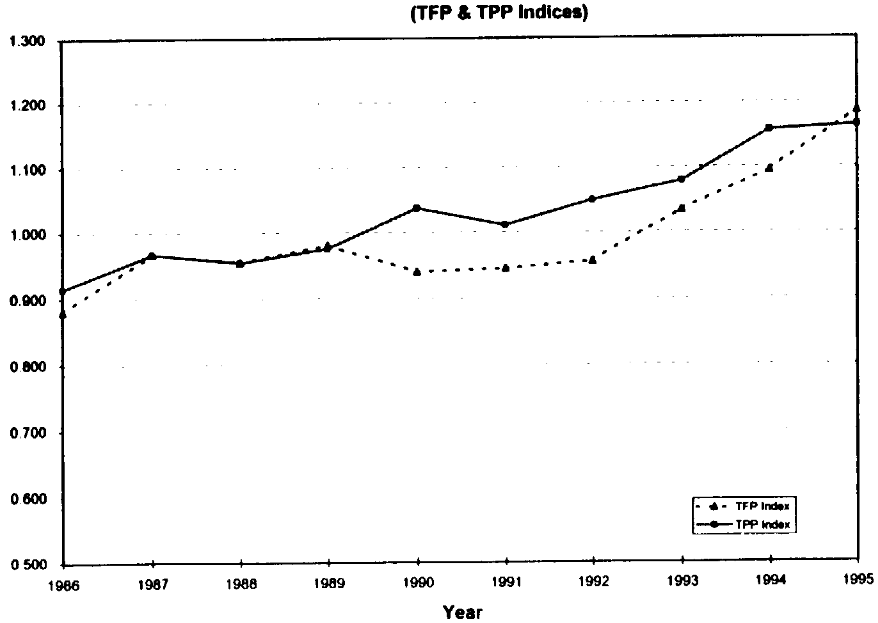


Figure 12: Northwest Airlines
(TFP & TPP Indices)

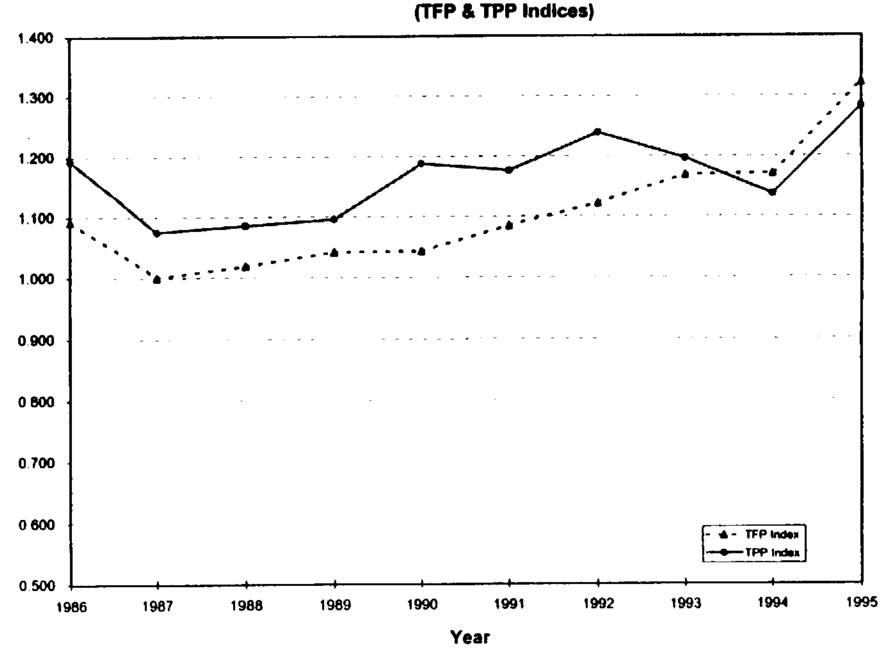


Figure 13: United Airlines
(TFP & TPP Indices)

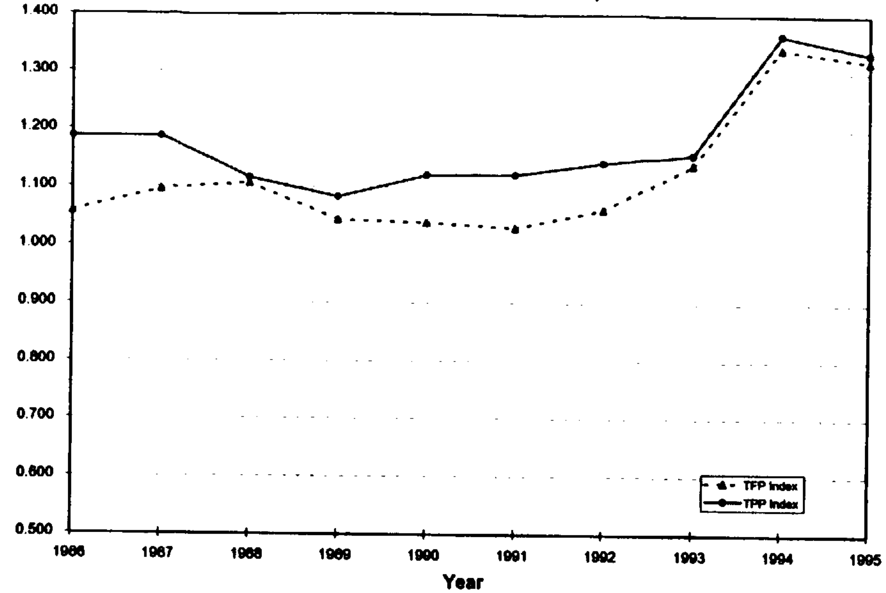


Figure 14: US Air
(TFP & TPP Indices)

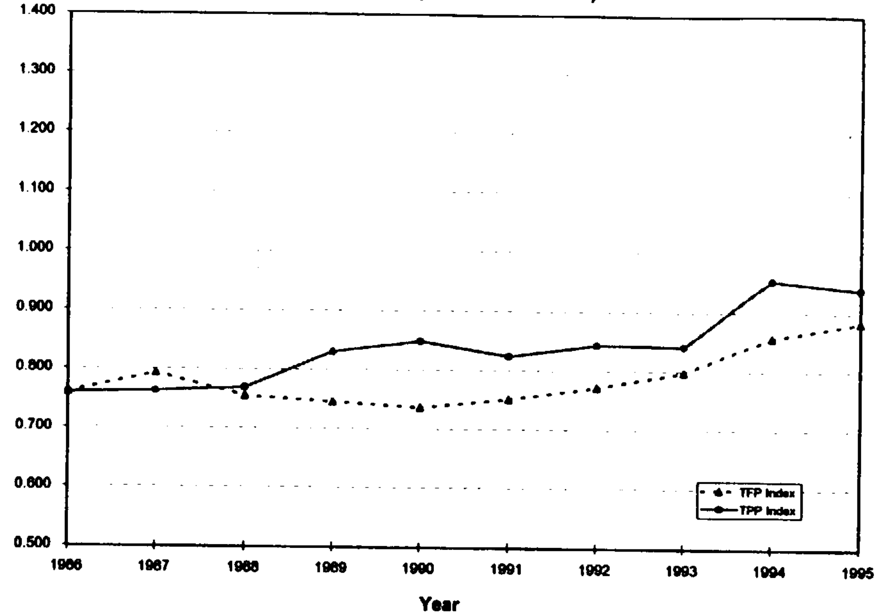


Figure 15: Air Canada
(TFP & TPP Indices)

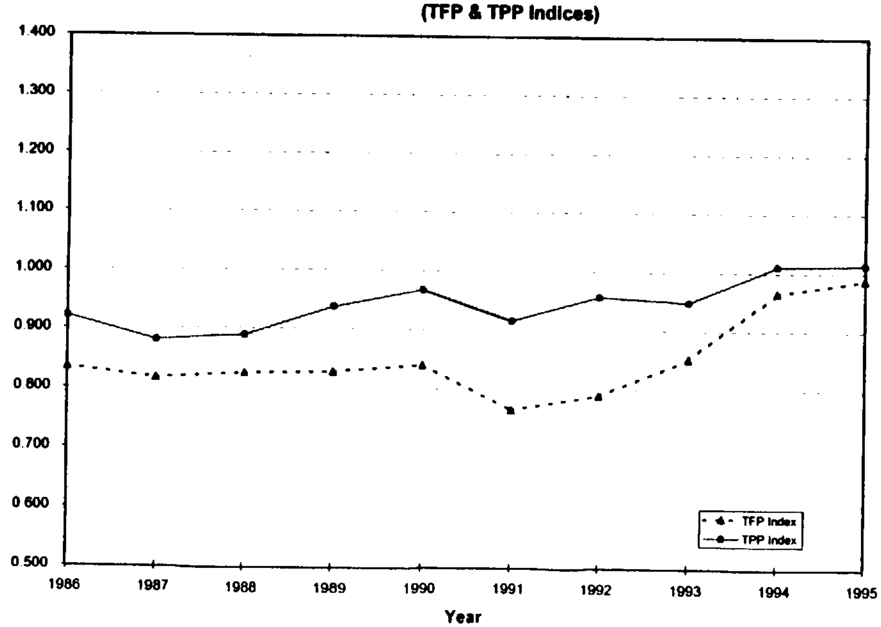


Figure 16: Canadian Airlines
(TFP & TPP Indices)

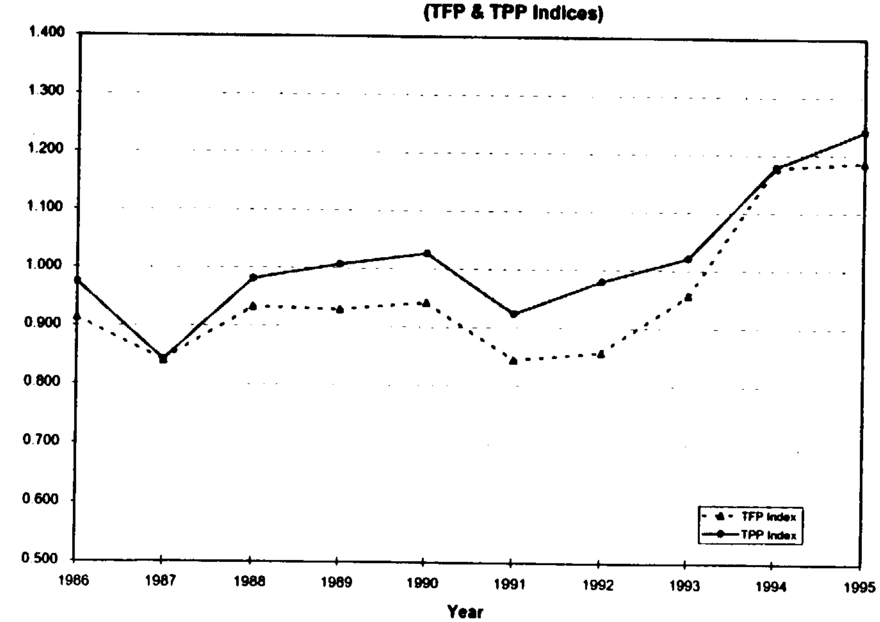


Figure 17: ANA
(TFP & TPP Indices)

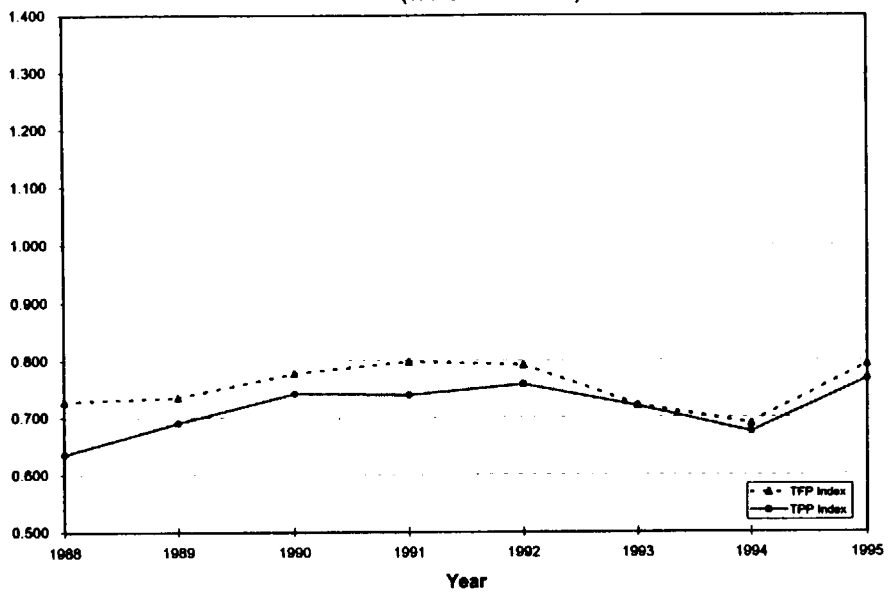


Figure 18: JAL
(TFP & TPP Indices)

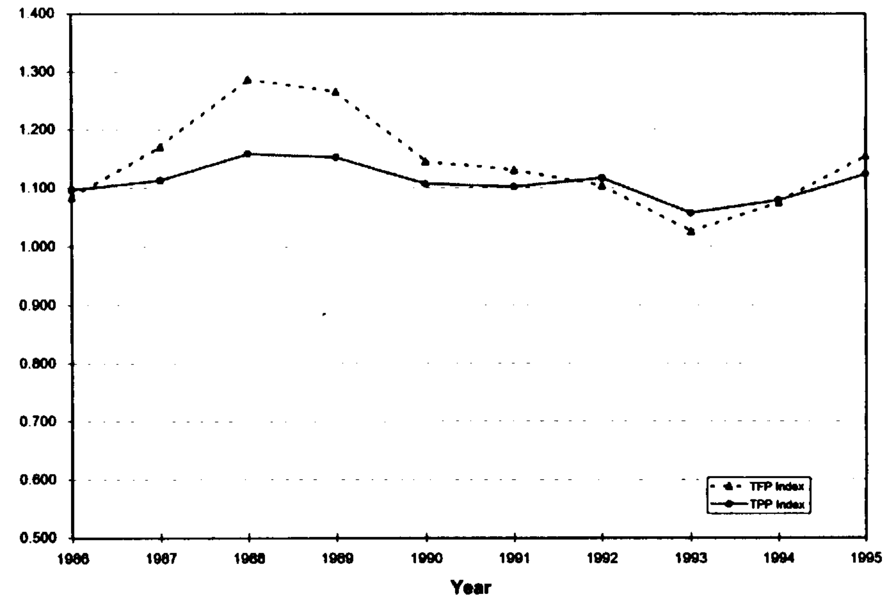


Figure 19: KAL
(TFP & TPP Indices)

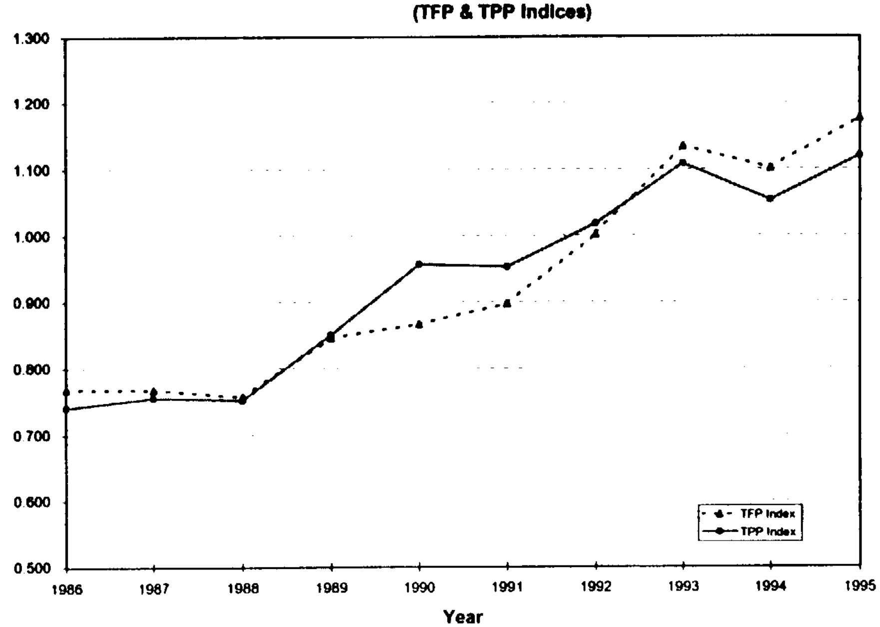


Figure 20: Cathay
(TFP & TPP Indices)

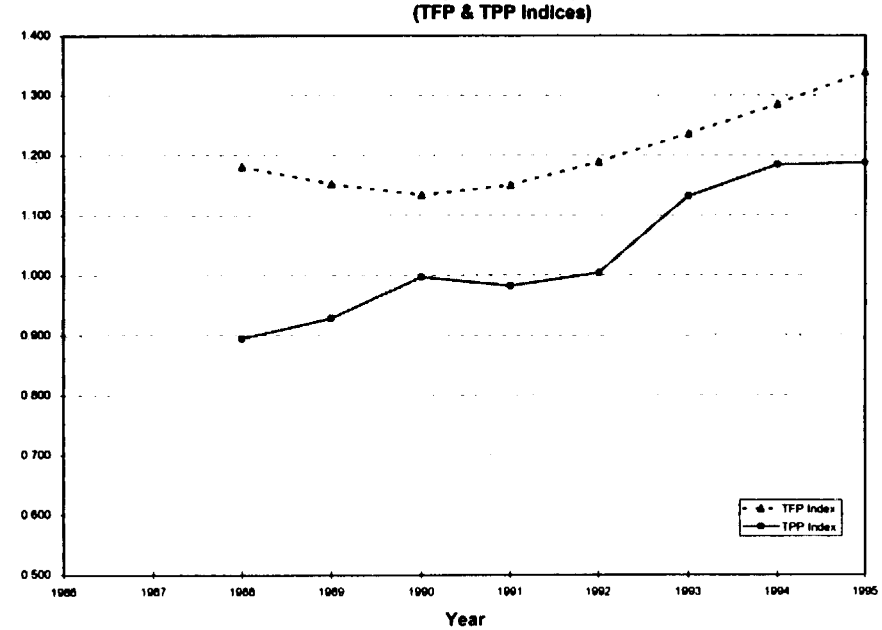


Figure 21: SIA
(TFP & TPP Indices)

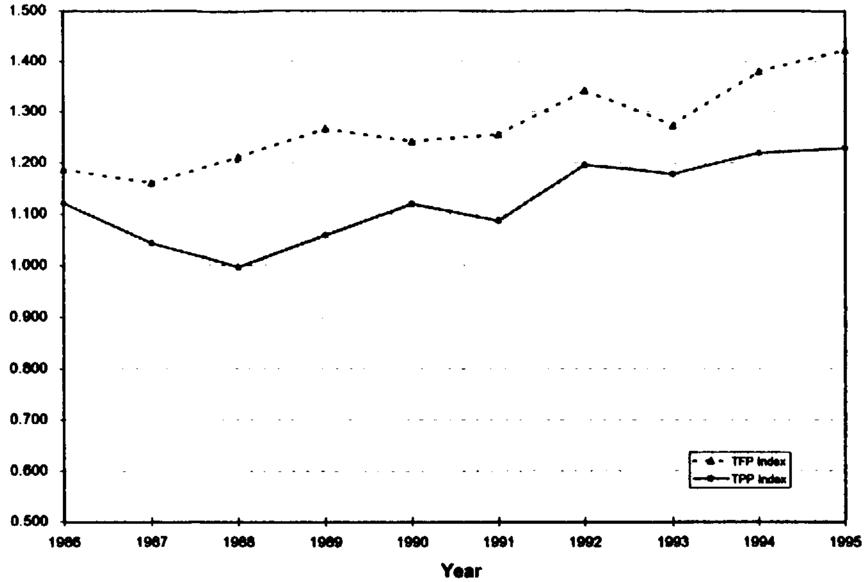
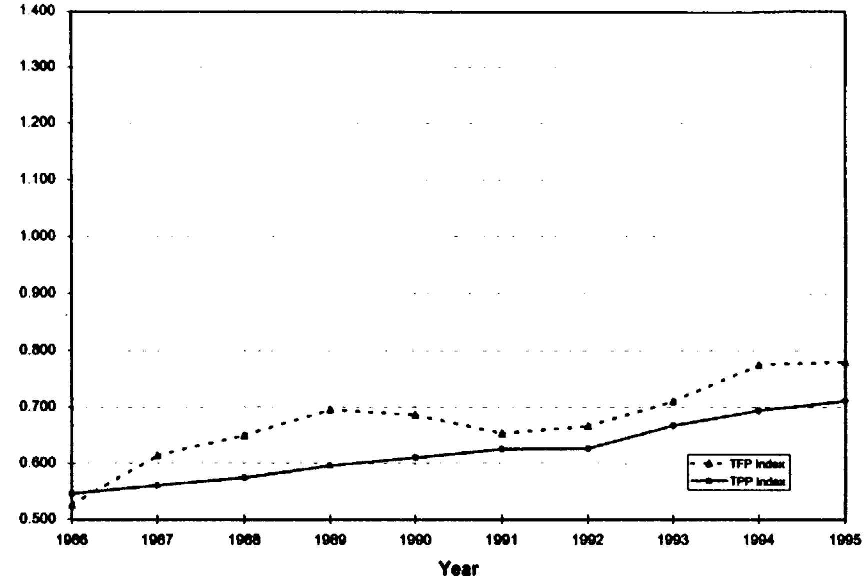


Figure 22: Thai
(TFP & TPP Indices)



KOREAN AIR PASSENGERS' CHOICE BEHAVIOUR

by
*Kwang Eui Yoo**

5/27

I. INTRODUCTION

Domestic air travel is unusual in Korea because the country is not large enough to take advantage of air travel. International air travel was severely regulated by government until the late 1980's, and besides regulation, the common people in Korea have not been wealthy enough to take frequent international trips. In such conditions, Korean people in general have not been accustomed to taking an airplane until recently. Now, many Koreans can have the chance to take a trip abroad, because the regulation against " going out of country " has been greatly eased by the act of " liberalisation of foreign travel " in 1988, and even the common people have the economic ability to use international air travel. It is therefore interesting as well as necessary to study particular people's behaviour in the relatively new situation of international air travel.

This research will study the choice behaviour of Korean people for their international air trips. It will concentrate on the study of flight choice behaviour by Korean air travellers who are travelling long distance to North America or Western Europe flying more than 10 hours. As an initial study of the Korean international air travel market, the major objective of the research is to identify the factors and their importance for flight choice, and with these findings, relative importance between variables will be estimated (for example, the value of travel time).

A disaggregate model will be more useful than an aggregate model to reach such objectives as described above. As a research method to calibrate models, Stated Preference(SP) Techniques will be utilised. Often it is not easy to calibrate an efficient model with Revealed Preference(RP) data because there is not sufficient variation of all variables of interest and there are also often strong correlation between variables or between variables and other invisible factors. SP Techniques which allow the researcher to experiment, can offer a solution to these

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problems. With clearly defined attributes and attribute levels, SP experiments can give researchers the chance to have sufficient variation of variables interests, and an orthogonal design which ensures that the attributes presented to respondents are varied independently from one another, avoids multi-collinearity between attributes. The drawback of SP Techniques is that the data obtained represent individuals' statements of what they would do given hypothetical choices. However, people may not necessarily do what they say. This disadvantage can be overcome by presenting respondents with as realistic a set of situation as possible. Therefore, it is desirable that SP design and data gathering process should be devised according to the information obtained from RP data. So, it is necessary to have sufficient quality RP data which will result reliable SP models.

The necessary RP data was gathered through the survey of this study because there has not been any research related to international air travellers' behaviour in the market, until now. The survey to gather RP data was conducted at passenger terminals of Kimpo International Airport in Seoul Korea, by distributing and collecting a self administered questionnaire. This paper will not present the detailed procedure of the survey and d data analysis. However, it was found that the surveyed RP data well represent the population (Yoo, 1995), and the findings from the data would be utilized for SP design as described in the section II.

II. SP DESIGN PROCEDURE

1. Introduction

With clearly defined attributes and attribute levels, SP experiments can give researchers the chance to have sufficient variation of variables of interest, and an orthogonal design which ensures that the attributes presented to respondents are varied independently from one another, avoids multi-collinearity between attributes.

However, strict orthogonal design might be undesirable in some circumstances as strict orthogonal design often produces too many alternatives for respondents to manage. In addition, where the orthogonal design concept is strictly applied, it could produce unrealistic options. For example, travel time and travel cost should be correlated in some circumstances. In such cases, the alternatives composed by strict orthogonal design which secure complete independence in variation of attribute level would be ridiculous to respondents. Since people may not actually do what they indicate in their response to a hypothetical situation, the reality of the hypothetical alternatives is very important in order to induce reliable responses from the respondents. Therefore, a compromise between orthogonality and reality is usually unavoidable for the SP design.

Another point to be considered for the SP design is simplicity in order to lead the respondent to view the hypothetical options consistently and logically without fatigue. To secure simplicity in the design, it is necessary to reduce the number of alternatives. This will require a limit on the number of attributes and their levels.

The subsequent subsections will describe the concrete procedure of the SP design for this research. These will include the design of the response measurement scale, attributes and their level selection, hypothetical alternative composition, and the alternative set composition.

2. Response Measurement Scale

There are three kinds of measurement scales which have been used for SP experiments: ranking across options, rating each option, and choices among options. The selection among these three measurement scales depends on the purpose of research, survey environment and the method to be used for analysis. The survey environment of this research is compatible with choice experiments because the survey is conducted in an airport departure lounge, and the respondent does not have enough time to consider rating or ranking the alternatives. The choice data can be analysed through logit modelling, which allows statistical testing.

3. Attributes Selection

All the factors influencing air passengers' flight choice should be included in the attribute set to understand travellers' behaviour. However, it must be pointed out that few respondents are consistently adept at evaluating many attributes at a time. Therefore, it is a major concern at the initial stage of SP design to select a few important attributes and set their level considering reality, and simplicity of the hypothetical alternatives.

The major factors influencing air flight choice in the market were found through the RP data analysis. They were as follows; *air fare, air journey time, service frequency, and the nationality of airline*. These four factors can be adopted as good attributes for the SP experiment, as they have reality as identified through observed behaviour. The remaining part of this subsection will describe a detailed definition for each attribute.

Air Fare

The air fare represents the actual ticket price paid by travellers. This study will only consider the air fare for economy class, and the samples for the SP survey are selected from economy class travellers, in order to simplify the SP experiment. However, it is necessary to know how the corporate business travellers, who are the employees of large corporations, consider the air fare attribute for their flight choice, as the air fare is often paid by the corporation they are employed by, for their business travel. The findings obtained from RP data show that about 90% of business travellers usually considered the ticket price because the company or department to which they belonged had a budget constraint for travel (Yoo, 1995). Therefore, the air fare factor must be included in the attribute set for business travellers, as well as leisure & VFR travellers.

Journey Time

Because almost all of the flights in the market of this study, use the same departure and arrival airport for the same destination city, the SP design consider air journey time for the travel time factor.

There were no significant differences in flying time between the services of each airline for the same destination if the flight was non-stop direct. The variation of air journey time depended on whether the flight was non-stop or an intermediate-stop one. That is to say, journey time is closely correlated to the existence/non-existence of an intermediate-stop. It is undesirable to include journey time and existence/non-existence of an intermediate-stop as an independent separate variable. It would be desirable to present one travel time variable which can represent the mixed effect of air journey time and intermediate-stop factors, in order to secure not only the reality of experiment but also to reduce the number of attributes.

Service Frequency

According to the RP survey data, many people answered they had chosen the flight because the "flight schedule" was suitable. Some of them may have been influenced by the departure date, some of them may have been influenced by departure time, and some of them may have been influenced by either arrival time or arrival date. It would be too complicated a design to manage if we considered those four aspects of time schedule as separate attributes. It is, therefore, desirable to use one attribute which can include all those aspects.

This attribute of "flight schedule" might be closely correlated with flight frequency. If there are more frequent flights for one flight number than another, it can result in more convenient time schedule. So, it is undesirable to include "flight time schedule", and "flight frequency" independently in the attribute set, and this study will use *service frequency* to include all these aspects stated above.

Nationality of Airline

Through the analysis of RP data, it was revealed that the nationality of the service provider was an important factor in flight choice. Many Korean travellers did not feel confident with speaking or listening and understanding English or other foreign languages. So, they prefer Korean airlines which served by Korean cabin crews, to foreign airlines. Perceived preference differentiation between Korean airline service and foreign airline service might be considered as service level factors.

4. Setting Attribute Level

Determining the level of attributes to compose hypothetical alternatives, requires considerable care in order to induce reliable responses from respondents. One serious constraint might be that the number of attribute levels should be limited, since the number of options which respondents consistently consider, is not large. A major consideration in selecting the level of attributes is range and degree of variation. Since the realistic levels of attributes are crucial to lead the respondents to a logical consideration, it is desirable to use the information observed within a real market, in order to set the range and degree of variation of attribute level. Customisation in selecting the attribute levels are also useful to ensure realism within the attribute level because different individuals may have different experience for the realistic level of attribute.

The factorial design has the advantage of orthogonality, whereas the alternatives can present an unrealistic combination of attribute levels. In such cases, such alternatives as seem unrealistic, should be removed in order to improve data quality, sacrificing the orthogonality of design.

Additional consideration for setting the levels of attributes is complexity and competitiveness. Complex choice tasks result in ignoring some attributes. Avoiding obvious dominance, and securing competitiveness in attractiveness of alternatives also lead respondents to consider their responses to the questions seriously, and so results in reliable data.

(1) Attribute Level of *Journey Time*

The air journey time means the time difference between take off time at the origin airport and landing time at the final destination airport. It was found through the RP survey that air journey time for the same destination varied according to the existence/non-existence of intermediate-stop. The flight hours for the same destination with a direct non-stop flight were almost all the same regardless of the flight number.

In SP design, journey time had to be customised by the samples' destinations, in order to secure reality in hypothetical alternatives. Three levels were assigned for this attribute: "L"(low), "M"(medium), and "H"(high). "L" level of journey time for each destination, was set at the average value of real data of non-stop flights for each destination. The "M" level was set at the value of three hours added to non-stop flights, as most one intermediate-stopping flights take two and half to three hours more than a non-stop flight in the market of this study. The "H" level was set at the value of five hours added to non-stop flights because it was revealed that some intermediate-stop flights took five hours more than a non-stop flight. The questionnaire had to notify respondents that the "M" and "H" levels of this attribute are only associated with one intermediate-stop.

More than one intermediate-stop was excluded from consideration because it was found in the RP survey that there were not enough respondents who had used such an air-route. Table II-1 shows the attribute level for each destination. Destinations were grouped by flight hours on a non-stop flight.

(2) Attribute Level of *Air Fare*

Need to Customise Air Fare Attribute

The air fares paid by travellers are systematically differentiated by several factors. It is desirable to customise the level value of air faire attribute to respondents' experience in order to secure reality in SP experiment.

According to the RP survey data, it was revealed that air ticket price was profoundly differentiated by residing country of the traveller. Notably, the people who lived in the USA paid far less than the people who lived in Korea for the same flight. It was also found that travellers normally preferred Korean airlines when other conditions were the same. The people who used Korean airlines usually paid more than the people who used foreign airlines for a trip with the same conditions.

This research decided to segment the respondents by mainly travelled destination, nationality of airline mainly experienced, and residential country, for the SP design and survey.

Correlation of level' value of journey time and air fare attributes

The air fare of non-stop flight is normally higher than that of intermediate-stop flight for the same destination because intermediate-stop flight takes longer to reach its destination. It would be desirable in the SP design to have a correlation between the travel time and the cost attributes in order to secure reality.

Table II-1

Attribute Level for Journey Time

(a) Los Angeles and San Francisco

Level Class	level's value (Int.-stop*)
L	11 hours (0)
M	14 hours (1)
H	16 hours (1)

(b) New York, Paris, Frankfurt, and London

Level Class	level's value (Int.-stop*)
L	13 hours (0)
M	16 hours (1)
H	18 hours (1)

* The value of "0" in the parenthesis means that the journey time is related to non-stop flight, the value of "1" means that the journey time is related to one intermediate-stop flight.

Considering the VOT which was roughly estimated through the RP data analysis, this research adopted the policy to correlate the level value of journey time attribute and air fare attribute as follows. If an alternative was composed with the "M" level of *journey time*, the air fare attribute level was set at 130 dollars less than the corresponding level's value of a non-stop flight. In the case where an alternative is composed with the "H" level for the *journey time*, the *air fare* level was set at a value of 40 dollars less than the corresponding alternative of "M" level of *journey time*, thus making it 170 dollars less than the corresponding alternative with a non-stop flight.

Setting Air Fare Attribute Level

Although it is desirable to assign many levels for the air fare attribute because of its importance in consumer choice behaviour, if there are more than three levels, then it results in too many alternatives for the respondents to manage. Therefore, three levels were applied for the air fare attribute; "H"(high level), "M"(medium level), and "L"(low level). The actual value for each level was assigned considering the ticket price for each segment within the real market. "H"(high) level reflected the average ticket price of each segment which was found through the RP data analysis of this study. "M"(medium) level was set at the value subtracting 10% from high level, and "L" level was set at the value subtracting 20% from high level(see table II-2). These decreasing rates of 10% and 20% were determined by considering reality. The "M"(medium) levels set by this method are set at around the minimum price of the RP data. The "L"(low) levels are set at lower than the minimum price of the RP data. This low value is justified because the air fare within the market of this study is on a declining trend.

(3) Attribute level of *service Frequency*

For the customisation of level's value for the *service frequency* attribute, samples should be segmented by destinations as there is a significant variation of service frequency by destination city. Two levels were assigned to this attribute; "H"(high) level and "L"(low) level. "L"(low) level represented the level of current service frequency, and "H"(high) level represented the level of improved service frequency.

Table II-3 shows the level's value of *service frequency* attributes. Frequency values for the "L" level was determined by reflecting current service frequency per week by airline nationality. Where there was a difference in the number of flights offered by Korean airlines and foreign airlines, then the larger number was adopted.

However, it was found that when people plan long distance air travel in the situation of such a low frequency market, their concern was for the convenience of a departure-arrival date or time, without reference to time intervals between departure or the number of services per week. Therefore, it is necessary that the service frequency should be translated to the degree of convenience for the departure or arrival time for the SP questionnaire in order to induce reliable answer from the respondent.

Table II-2

Level's Value for Air Fare Attribute

a. Destination of Los Angeles and San Francisco

(1) Segment 1,(For Korean airline User, Korean Resident)

air fare level / journey time level	L	M	H
L (non-stop flight)	$ 700	$ 790	$ 880
M (3 hour longer, Int.-stop)	$ 570	$ 660	$ 750
H (5 hour longer, Int.-stop)	$ 530	$ 620	$ 710

(2) Segment 2 (For Korean airline User, USA Resident)

air fare level / journey time level	L	M	H
L (non-stop flight)	$ 540	$ 610	$ 680
M (3 hour longer, Int.-stop)	$ 410	$ 480	$ 550
H (5 hour longer, Int.-stop)	$ 370	$ 440	$ 510

table II-2 continued

(3) Segment 3 (For Foreign airline User, Korean Resident)

air fare level / journey time level	L	M	H
L (non-stop flight)	$ 660	$ 750	$ 830
M (3 hour longer, Int.-stop)	$ 530	$ 620	$ 700
H (5 hour longer, Int.-stop)	$ 490	$ 580	$ 660

(4) Segment 4 (For Foreign airline User, USA Resident)

air fare level / journey time level	L	M	H
L (non-stop flight)	$ 520	$ 590	$ 650
M (3 hour longer, Int.-stop)	$ 390	$ 460	$ 520
H (5 hour longer, Int.-stop)	$ 350	$ 420	$ 480

b. Destination of New York

omitted

c. Destination of European Cities(Paris, Frankfurt, London)

omitted

If there is one flight or more than one flight per day, usually being seven flights per week or more, then most passengers can depart or arrive on the day that they want. If there are fewer than seven flights per week, passengers' choice of travel day is limited. For travel to European cities, the "L" (low) level was set at the value of three flights per week, and "H"(high) attribute level was set at seven flights per week, i.e. daily service. "H" level represented daily service, which was represented as the statement "convenient flight date" to the respondents for the purpose of the questionnaire. "L" level, which meant three flights per week as frequency of the same level as the real market, was represented as "inconvenient flight date". Respondents were to be informed through questionnaire that a "convenient flight date" meant that they can travel on the day they want and an "inconvenient flight date" meant that choice was restricted to either a day before or after the day he/she required.

For the destinations of New York, San Francisco, and Los Angeles, "L"(low) level was set at the value of seven flights or more per week, which meant there was a daily service available. Under such circumstances, every one can depart on the day they want, if there are seats available on that flight. "H"(high) level meant two flights or more per day, which gave the traveller the chance to choose a convenient departure time. Under such circumstances, it might be reasonable to say that "L" level is translated to "inconvenient flight time schedule", "H" level is translated to "convenient flight time schedule", for the purpose of the SP questionnaire.

In conclusion, table II-3 can be translated to a verbal expression for the SP questionnaire. Table II-4 shows this verbal expression of table II-3 for the SP questionnaire composition.

(4) Attribute Level of *Nationality of Airline*

The *nationality of airline* had two levels. "H"(high) level was for Korean airlines which also includes Korean Air, and Asiana Airlines. "L"(low) level was for all foreign airlines. This attribute is the 'dummy' variable in which the level value of "0" is for Korean airline, and level value of "1" is for foreign airlines.

5. Composition of Hypothetical Alternatives

Three levels were assigned for each attribute of *journey time* and *air fare,* and two levels were assigned for *service frequency* and *nationality of airline* attribute. Although the level's value of *air fare* and *journey time* were correlated, the combination of each level would be independent.

If a full factorial design is used, there would be 36 combinations of alternatives, with two three level and two two level attributes. This would end in an unmanageable number of choice sets. It is, therefore, desirable to use fractional factorial plans to estimate the main effects only, assuming interactions to be negligible, in order to reduce the number of alternatives to a manageable size. The fractional factorial plan which estimates the main effects only, produces nine options which secure orthogonality between attributes. Table II-5 shows these nine combinations of attribute level.

Table II-3

Level Values for *Service Frequency* Attribute

attribute level / destination	L	H
Los Angeles	28	56
New York	14	28
San Francisco	7	14
Paris, Frankfurt, London	3	7

Table II-4

Level Values for *Service Frequency* translated to Verbal Expression For SP Questionnaire

attribute level / destination	L	H
Los Angeles	inconvenient flight time schedule	convenient flight time schedule
New York	inconvenient flight time schedule	convenient flight time schedule
San Francisco	inconvenient flight time schedule	convenient flight time schedule
Paris, Frankfurt, London	inconvenient flight date	convenient flight date

Table II-5

Experimental Design of Alternative Composition with Two Three Level Attributes and One Two Level Attribute

	Time (3 levels)	Air Fare (3 levels)	Frequency (2 levels)	Nationality (2 levels)
Alt. 1	L	L	L	L
Alt. 2	L	M	H	L
Alt. 3	L	H	L	H
Alt. 4	M	L	H	H
Alt. 5	M	M	H	L
Alt. 6	M	H	L	L
Alt. 7	H	L	L	L
Alt. 8	H	M	L	H
Alt. 9	H	H	H	L

6. SP Questionnaire Composition

The SP survey would be conducted in the departure lounges of Kimpo International Airport. The questionnaire needed to be simple and easy to answer as air passengers waiting in departure lounges do not have enough time to consider complicated questions. Because of the extreme time constraints on air passengers in the departure lounge, it was needed to make the SP experiment a pairwise choice game. The samples would be Korean air travellers who are going to take a flight to a specified destination.

The questionnaire was composed of two parts. The first part was for segmentation of the samples for the customisation of the attribute levels. The second part was for the main SP experiments which was composed of a pairwise choice game of hypothetical alternatives. There were 36 choice pairs which were constructed from 9 alternatives. Among the 36 pairs, 8 pairs were composed of one dominated alternative and one dominant alternative in every aspect of the attribute level, and the other 28 pairs were composed of competitive alternatives. Since these are too many choice pairs for one respondent to answer in a short time, those pairs were divided into three groups. So, three respondents were necessary to complete one whole set of choice pairs. One dominated-dominant pair was included in each group to test that the respondent conducted the choice experiment properly.

III. SP Survey

The questionnaire and technical procedure of main SP survey was finalised through pilot survey. For the main SP survey the sample segmentation by destination and airline nationality was applied to the sampling plan. Since destination and airline nationality could be distinguished by flight number, there was no difficulty to select the intended number of respondents for each segment. The composition of the number of the sampled passengers by destination and airline nationality for the SP experiment needs to be similar to that of the RP surveyed data, because observation composition of RP data is representative of the population. So, quota sampling strategies were applied. Table III-1 shows the numbers of samples assigned for each destination and for each airline nationality, reflecting RP data composition of this study.

Table III-1

Number of Samples Assigned to each Segment for Main Survey

destination	*airline's nationality*	*number of samples assigned*
Los Angeles	Korean airline user	192
	foreign airline user	102
New York	Korean airline user	141
	foreign airline user	81
San Francisco	Korean airline user	42
	foreign airline user	72
European Cities	Korean airline user	99
	foreign airline user	42

TOTAL		771

The place of the survey was the departure lounge of Kimpo International Airport Passenger Terminals. The method of survey would be to interview with presenting questionnaire, by four interviewers including the author. Flight numbers to designated destinations, were selected, and the interviewers tried to be at the corresponding gate's departure lounge, 90 minutes earlier than the take off time, with the survey questionnaire which corresponds to the destination and airline nationality of the flight number.

At first, an interviewer approached every Korean traveller arriving at the departure lounge more than 40 minutes before take off time, and presented the first part of the questionnaire mainly for segmentation of samples. Any of the other three interviewers approached the travellers who had finished the first part of questionnaire, and after reviewing their answers, the interviewer decided the segment cell to which the respondent belonged. They were then presented with the corresponding second part of the questionnaire, which included the main SP choice experiments.

If it was revealed that the current journey purpose of a respondent was business (or leisure & VFR) by the answer to the first part question, he/she was presented with the second part questionnaire for business travellers (or leisure & VFR travellers). The difference of questionnaire for business travellers and for leisure & VFR travellers is only the difference in the assumption of the hypothetical choice game which is included in the introductory section of the second part of the questionnaire.

If it was revealed that the main residential country was Korea (or foreign country) by the answer to the first part question, he/she was presented with the second part questionnaire for Korean residents (or foreign residents). The difference of questionnaire for Korean residents and for foreign residents is the difference in value of levels of the *air fare* attribute, as stated in section II.

Among the business travellers, 457 samples participated in the SP survey. 16 respondents among those 457 respondents were proved to have conducted the SP choice experiment carelessly by choosing dominated alternatives in the dominant-dominated pair, or alternative "A" (or "B") for all the questions. Among the leisure & VFR purpose travellers, 470 samples participated in the SP survey. Twenty three respondents among those 470 respondents were proved to have conducted the SP choice experiment carelessly.

IV. Logit Model Calibration with SP Data

1. Input Data for Model Calibration

441 respondents as business travellers, and 447 respondents as leisure & VFR travellers, were finally selected as input data for logit analysis. These compose 147 (=441/3) sets of whole choice pairs for business travellers, and 149 (=447/3) sets of whole choice pairs for leisure & VFR travellers, because three respondents compose one whole set of choice pairs.

For *service frequency* attribute, the verbal expression in the questionnaire is translated to number of flights per week, the same way as it was translated from number of flights per week to verbal expression, at the SP design stage. For example, for the respondents travelling to Los Angeles, "convenience departure time" is translated to 56 flights per week, "inconvenient departure time" is translated to 28 flights per week. For the attribute of *nationality of airline,* the value of "0" was assigned for Korean airlines, and the value of "1" for foreign airlines.

2. Calibration Results and Model Validation

Logit models were calibrated with SP data defined in the previous section, utilising ALOGIT software produced by Hague Consulting Group (Daly, 1988). The model estimates would test the hypothesis that travellers preferred low air fare, short journey time, high frequency service, and Korean nationality of airline. The model would also identify the degree of importance of those variables for air flight choice in the market. The utility function of the model can be expressed as:

$$U = a_1\ JT + a_2\ FARE + a_3\ FREQ + a_4\ NATION$$

where: JT is the journey time expressed by the unit of minute
FARE is the air fare expressed by the unit of US dollar
FREQ is the number of flights per week
NATION is the nationality of airline; "0" for Korean airlines, "1" for foreign airlines
a_1, a_2, a_3, a_4 are for the coefficients to be estimated.

A separated model was calibrated for business travellers and leisure & VFR travellers. Table IV-1 shows the parameter estimates with the corresponding t-values, the likelihood ratio test, and the Rho-square.

The values of likelihood ratio test can reject the null hypothesis that all the parameters are zero at the 0.01 level of significance. That means the hypothesis of independence between the model probability and explanatory variables can be rejected. The value of "Rho-squared" is used to measure the goodness of fit of the model. "Rho-squared" value of 0.1997 for business travellers, and 0.2024 for leisure & VFR travellers indicate the model fit is not very good but not bad.

All the coefficients have the right sign. Negative signs for the coefficients of *journey time* and *air fare* attributes indicate the passengers dislike high travel cost and long journey time as expected. Positive signs for the coefficient of *service frequency* attribute is also as expected. A negative sign for the coefficient of *airline's nationality* indicates that Korean passengers prefer Korean airlines to foreign airlines which is also expected.

Table IV-1

SP Model Calibration Results

segments by journey purpose / coefficients	*Business*	*Leisure & VFR*
a_1	-0.008036 (-22.6)	-0.007266 (-20.5)
a_2	-0.008629 (-21.4)	-0.009041 (-21.8)
a_3	0.04625 (18.8)	0.06026 (19.8)
a_4	-0.1181 (-2.2)	-0.09272 (-1.7)
Likelihood ratio test	923.5	955.8
Rho-squared	0.1997	0.2024
$X^2(0.01,\ 4)$	13.28	13.28
(t-values are shown in parenthesis)		

Journey time, air fare, and service frequency parameters are significant at 99 percent level. The *nationality of airline* parameter is found to be significant at 90 percent level for the business travellers, and a little bit poorer than 90 percent confidence level for leisure & VFR travellers.

With the values of likelihood ratio test, Rho-squared, and the sign and t-value of coefficient estimated, it was internally validated that the models were generally good. However, it is very desirable to validate the model with external data, if it is possible. Since the principal drawback of the SP method is that individuals' stated preferences may not correspond closely to their actual preferences, external validation of the SP model is seriously recommended, although the external validation of the SP model has not been common in practice because of lack of suitable real world data.

Fortunately, there are revealed preference (RP) data obtained through the survey, which can be used to validate the model calibrated with the SP data. Since each of these RP data records is composed of the same variables as SP data, it is not difficult to validate the SP model by estimating the prediction success rate. That is, the utility of each alternative in the RP data was calculated by replacing the value of each variable in an RP alternative on the SP model, and then, it was checked that the utility of the chosen alternative was the highest. In the case that the chosen alternative had the highest utility among all the alternatives available to the respondent, the prediction was considered a success. The overall prediction success rate was revealed to be more than 70%, which could be considered as a good fit of model. So, these SP models were also validated as a good fit by the external data.

3. Results Analysis - Relative Importance of Variables

Since it was calibrated with hypothetical alternatives, the absolute value of any one sole coefficient in the SP model needs more external information to be used for the interpretation of the value. Instead, the SP model is useful for seeing the relative importance which can be estimated by comparing the absolute value of coefficients.

Several ratios calculated by comparison with any two coefficients would be presented to analyse the air travellers' choice behaviour in the market.

(1) Value of Travel Time (VOT)

The most frequently utilised relative importance in transport studies, is the ratio between travel time value and travel cost value, which is usually mentioned as value of travel time(VOT). VOT can be calculated utilising the formula;

$$VOT = a_t / a_c$$

where; a_t is the coefficient of time variable (*journey time* variable in this case)
a_c is the coefficient of cost variable (*air fare* in this study)

Table IV-2 shows VOT for business travellers and that for leisure & VFR travellers. From the information in this table, it can be said that the business travellers in the market would be prepared to pay 93 cents more to reduce 1 minute of journey time, and leisure & VFR travellers would be prepared to pay 80 cents more to save 1 minute in air travel time. The result that the VOT of business travellers is bigger than that of leisure & VFR travellers appears normal.

Table IV-2

VOT by Journey Purpose

journey purpose	*VOT*
Business	0.93 (US $/minute)
Leisure & VFR	0.80 (US $/minute)
average (business and Leisure & VFR)	0.87 (US $/minute)

(2) Additional Value to Pay for Korean Nationality of Airline

Through the study of observed preference in the market, it was identified that Korean airlines are preferred to foreign airlines by Korean international travellers. The models calibrated with SP data also show that respondents prefer Korean airlines to foreign airlines, as stated at previous sub-section. It is possible to estimate how much more the traveller would like to pay to take a Korean airline, by comparing the coefficient of *nationality of airline* to the coefficient of *air fare*, as expressed by the following formula:

Additional Value to Pay for Korean nationality of airlines = a_n / a_c

where; a_n is the coefficient of nationality, which is significant at 90% level for business travel and 80% for leisure & VFR travel models.
a_c is the coefficient of air fare, which is significant at 99% level.

Table IV-3 shows the additional value to pay for Korean airlines. It shows that business travellers are willing to pay more than leisure & VFR travellers in order to take Korean airlines. This suggests that business travellers place more weight on the service factor which is represented by comfort obtained through language and cultural identity. The last column of the table shows the values estimated considering the distance. These values represent the premium value for every thousand kilometres for a traveller to pay in order to take a Korean airline.

Table IV-3

Additional Value to Pay for Korean Airlines

journey purpose	*Value for Korean Airline*	*Value for Korean Airline (cents / 1000 kilometre*)*
Business	13.7 (US $)	114 (cents/1000kilometre)
Leisure & VFR	10.3 (US $)	86 (cents/1000kilometre)
Average	12.0 (US $)	100 (cents/1000kilometre)

* The values in this column were estimated assuming that the distance is 12,000 kilometres on average.

(3) Value to Pay for Service Frequency Increase

Relative importance of *service frequency* to *air fare* can also be calculated utilising the following formula:

$$\text{Value to pay for } \textit{service frequency} \text{ increase} = a_f / a_c$$

where; a_f is the coefficient of *service frequency* variable
a_c is the coefficient of *air fare* variable

Table IV-4 shows the relative importance of *service frequency* to *air fare*. It is an unexpected result that leisure & VFR travellers place higher value on service frequency than business travellers. It can be roughly explained that since the industrial structure in Korea is manufacturing centred, the majority of business travellers are from big or small manufacturing companies or professional technicians, who are not compressed by tight time schedules, and they do not care seriously about the convenience of the flight schedule. Instead, they care about a comfortable journey and short journey time. (However, this research does not study in detail the reasons why business travellers care less about the service frequency. It must be reserved for further study.)

Table IV-4

Value to Pay for *service frequency* Increase

journey purpose	*Value of Frequency Increase*
Business	5.36 (US $ / 1 flight per week)
Leisure & VFR	6.67 (US $ / 1 flight per week)
Average (business and leisure & VFR)	6.02 (US $ / 1 flight per week)

(4) Trade-Off between *service frequency* and *travel time*

The relative importance between service frequency and travel time is estimated utilizing the following formula, and the results are presented in the table IV-5. This kind of value could be useful information for airlines' route planning. The choice between a hub-spoke route and a direct route depends on the consideration of trade-off between service frequency and travel time. Hub-spoke route planning usually increases the frequency between major cities sacrificing the travel time. On the other hand, the direct route has an advantage of short travel time with low frequency available.

Trade-Off Ratio between *service frequency* and *travel time* = a_f / a_t

where; a_f is the coefficient of *service frequency* variable
a_t is the coefficient of *journey time* variable

Table IV-5

Trade-Off between *service frequency* and *travel time*

journey purpose	*Trade-Off Ratio*
Business	-5.75 (minutes /1 flight per week)
Leisure & VFR	-8.29 (minutes / 1 flight per week)
Average (business and leisure & VFR)	-7.02 (minutes / 1 flight per week)

V. Conclusion

The SP model was calibrated and validated as good to be utilised for analysis of air flight choice behaviour in the market. The models calibrated with SP data are most appropriate for estimation of relative importance of variables. In this study, the relative importance of variables was estimated by comparing each variable's coefficients.

In the transport area, the most frequently utilised relative importance is the trade off ratio between travel time and travel cost, which is often expressed as VOT. VOT in the market was found to be about 87 cents per minute. It was also found that the VOT of business travellers is higher than that of leisure & VFR travellers, as expected. In the situation of the market in this study, the purpose of saving travel time with additional cost might be traveller's desire to lessen the uncomfortability caused by long time flight.

The value of taking Korean airlines which are mainly discriminated from foreign airlines, by the service in Korean language, Korean crew, Korean food or other cultural aspects, is 12.0 US dollars. However, through RP data analysis, it was revealed that the amount which Korean airline users paid in comparison to foreign airline users ranged from 30 dollars to 130 dollars more, according to the segment classified by destination and residential countries. This means that Korean international passengers preferred Korean airlines to foreign airlines, more heavily in the real market than their stated preferences. This might be because Korean airlines could have an advantage in marketing activities or some other advantage as home country carriers, the travellers chose Korean airlines in spite of more significantly differentiated prices than their intention. It has also been revealed that business travellers are willing to pay more extra money for Korean nationality of airline than leisure & VFR travellers. This seems to say that business travellers place more weight on in-flight service than leisure & VFR travellers.

The SP model also shows that the value of one additional flight per week is about six dollars and trade-off ratio between service frequency and travel time is about 7 minutes per flight. The VOT and the value of service frequency could be useful information for air transport planning in the subject market.

The competition in the Korean air transport market will be more severe in near future. This will lead to variety of choice options for air travellers. So, the research activities should also be more various and more refined SP techniques should be applied.

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A Model for Air Passengers Choice of Flight and Booking Class
- a Combined Stated Preference and Revealed Preference Approach

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1. Introduction

Passenger demand varies, whereas aircraft capacity is fixed in the short term. This many times implies reject situations; the prospective passenger cannot book on his preferred flight and class. Once rejected the passenger can deviate to a competitor (or just stay home); alternatively he can book on another flight on the same airline; or he can buyup, then paying a higher fare in order to be accepted on the higher class. In 1994, Scandinavian Airlines System (SAS) took the initiative to a collaboration with the Royal Institute of Technology (KTH) concerning a project aiming at estimating deviation, recapture, and buyup; the estimates should be used for improving the class allocations in the airline's yield management systems. The KTH part of the project was to design and analyse Stated Preference (SP) experiments, and to support the field interviews for this. KTH also should model the choices of flight and booking class that were retrieved from booking process data supplied by SAS, then using the Revealed Preferences technique (RP). The two models were jointly applied to estimating buyup and recapture, and implied corrections of seat allocations were assessed. This paper describes the work that has been carried out and the results achieved, in terms of some models as well as suggestions for continued research.

Interviews were made with a sample of passengers travelling on flight departures from airports A, B, and C on six routes during two weeks. Loggings of bookings from the reservations files for the same departures began about a month prior to the two week departure period. Since the project concerns a specific airline, and the information gathered might be strategic to competitors, some factors that were included in the analysis are not clearly defined; the geographic locations are not explicit, and the numerical results have been altered - although in a way that will not influence the discussion in any principal way.

2. Modelling choice of flight and booking class

The bookings reflect the actual outcome of a choice process, in which each reservation represents a choice of flight and booking class. This choice may in some cases be made by the passenger himself and in some cases by someone else, such as the employer or the travel agency. The bookings represent the behaviour that SAS actually faces in the market place. For these reasons, methods for analysing discrete choice should be applicable. In this particular case, focus is largely on the availability of alternatives which varies over individuals and thus makes it desirable to base such an analysis on disaggregate data. Analyses of bookings (revealed preferences) alone are however not sufficient for making estimates of deviation, recapture, and buyup. The RP data should be supported by stated preferences (SP) derived from interviews with passengers at the gates and inflight. Such a procedure has been proposed in the literature [3].The "logit model" is a widely used mathematical model of the theory of discrete choice [1]; in the project it was used for analysing RP choices as well as SP choices.

A basic assumption in discrete choice analysis is that each alternative in the choice set of a decision maker is associated with a utility, and that the decision maker chooses the alternative with the highest utility. The utility is assumed to consist of one observable part, and one part that is not observable for the analyst. Thus,

$$U_i = V_i + \varepsilon_i, \quad (1)$$

where	U_i	the total utility for alternative i,
	V_i	the observable part and
	ε_i	the unobservable part.

The unobservable part is assumed to be stochastic. This means that we will not be able to predict what alternative a decision maker will actually choose; but an assumption on the distribution of the stochastic part will allow us to predict the probability that it will be chosen. For a population of decision makers, we will thus be able to predict the share of the population choosing each alternative.

The assumption on the distribution of the stochastic part of the utility determines the functional form of the model. In the logit model case the assumption is that it is identically and independently Gumbel distributed (the Gumbel distribution is fairly close to the Normal distribution, the latter corresponding to the so called probit model). This distribution assumption implies the following formula for the probability to choose a particular alternative (the multinomial logit model):

$$P_i = \frac{e^{\mu V_i}}{\sum_{j \in C} e^{\mu V_j}} \quad (2)$$

where	P_i	the probability for a decision maker to choose alternative i
	μ	a scale parameter (inversely proportional to the standard deviation of the stochastic term)
	V_i	the observable part of the utility
	C	the choice set of the decision maker

In practice, V_i is often assumed to be a linear function of parameters and variables. The model can then be formulated as:

$$P_i = \frac{e^{\beta' x_i}}{\sum_{j \in C} e^{\beta' x_j}} \quad (3)$$

where	β'	a parameter vector (to be estimated)
	x_i	a vector of variables for alternative i

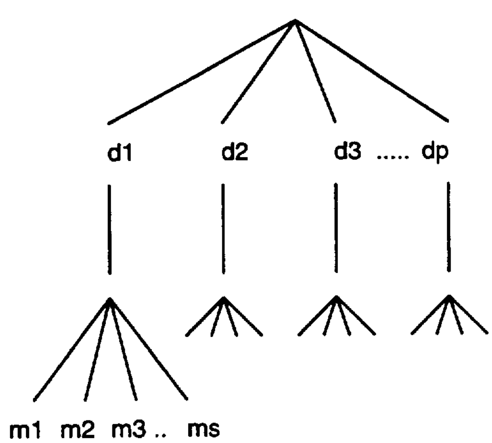
Thus, the β values reflect the sensitivity of the variables included in the model (such as price, service level, booking restriction etc.). The log of the denominator - the so called logsum - also has a useful property, in that it can be interpreted as the expected maximum utility of the alternatives in the choice set. The parameter vector β is estimated using the maximum likelihood method. The functional form of the logit model implies that the equations become non-linear; there however is special purpose software available for estimating β.

The assumption that the stochastic terms are independently and identically distributed is however fairly strong. It is very probable that some alternatives to some extent share the same unobserved part of the utility function - for example, two classes on the same flight will share the unobserved part of the utility of this flight. In this case, the alternatives can be structured in groups of alternatives, for example booking class alternatives and flight alternatives.

A structured logit model of class and flight choice can then be formulated in the following way. Figure 1 gives graphical illustration i of the structure:

$$P(d) = \frac{e^{\gamma' y_d + \alpha \ln \sum_{m'd} \exp(\beta' x_{m'd})}}{\sum_{d' \in D} e^{\gamma' y_{d'} + \alpha \ln \sum_{m'd'} \exp(\beta' x_{m'd'})}} \tag{4}$$

$$P(m|d) = \frac{e^{\beta' x_{md}}}{\sum_{m' \in M_d} e^{\beta' x_{m'd}}} \tag{5}$$



Eqn. (4)

Eqn. (5)

Figure 1. A structured logit model of flight and class choice

where

$P(d)$	the probability to choose flight d
y_d	a vector y of independent variables (attributes) for flight d
γ	the associated parameter vector γ, to be estimated
D	the set of p flight alternatives
ω	the logsum parameter (the ratio between the standard deviations of the error terms at the class choice level and the flight level), to be estimated
$P(m\|d)$	the probability to choose class m, given flight d
x_{md}	a vector x of independent variables (attributes) for class m and flight d
β	the associated parameter vector β, to be estimated
M_d	the set of s class choice alternatives for flight d

The x vector may contain continuos variables such as price, or discrete variables such as a dummy for a booking restriction.

The formulation of a structured model implies that the choice probabilities of the alternatives of one group is modelled conditional on the choice of alternative of the other group - in this example, class choice is modelled conditional on flight choice. Another implication is that the logsum is used to take the utilities of the alternatives of a lower (in the sense of the graph) group into account when modelling the probability for the alternatives of a higher group (or choice level).

The logsum parameter ω provides the connection between the choice levels, and should have a value in the range 0-1. If the logsum parameter takes the value of one, then the structured model is equivalent to the normal multinomial logit model. If the value is larger than one, unreasonable effects may be predicted, such as an increased ridership for one class caused by an improvement of another class (belonging to the same choice level).

3. Data for Modelling Choice of Flight and Booking Class

The data that can be retrieved from the booking process contain information on choices, availability of alternatives, and the characteristics of the alternatives in terms of variables defining departure times, prices, booking restrictions, service levels etc. To some extent, information on the passenger can also be retrieved. The pricing structure is however such that price, service levels and booking restrictions are highly correlated. It will therefore be difficult to obtain reliable parameter estimates of the different characteristics from the booking process alone. A big advantage of the data from the booking process is however that they do reflect the market preferences. Such data is often called Revealed Preference (RP) data.

In order to permit analyses of the impact of individual factors, Stated Preference (SP) experiments were carried out. This technique uses hypothetical choice alternatives, that are generated in such a way that the different factors are uncorrelated. In this project the air passengers were asked to state their choices between alternatives that were presented pairwise. This permits analysis of the data by means of a logit choice model, in which each choice between two alternatives is an individual observation.

It is generally concluded that stated choices may be biased, one important factor being that also other factors than those included in the SP experiment will influence the choice in real world decisions (Swait *et al.*, 1994). Models based on SP data should therefore be used for predicative purposes with great caution. The relative trade off between different factors in the SP model may however be less biased.

4. Combining Revealed and Stated Preference Data

RP and SP data have each their strengths and weaknesses. In recent years, however, a technique for joint analysis of SP and RP data that takes advantage of the strengths in both data types has been developed. Basically, this technique uses the trade off information of the SP data and the choice elasticity information in the RP data.

Technically, this can be achieved by "scaling" the utility function derived from the SP experiments to the context of the RP data. This can formally be described in the following way:

$$U_{SP}=V_{SP}+\varepsilon_{SP} \quad (6)$$
$$V_{SP}=\mu_{SP}\,\Sigma\beta_k x_k \quad (7)$$
$$U_{RP}=V_{RP}+\varepsilon_{RP} \quad (8)$$
$$V_{RP}=\mu_{RP}\,\Sigma\beta_k x_k=\lambda\mu_{SP}\,\Sigma\beta_k x_k \quad (9)$$

where

U_{SP} utility of SP alternative
V_{SP} observed utility of SP alternative
V_{RP} observed utility of RP alternative
μ_{SP} scale parameter of SP data
μ_{RP} scale parameter of RP data
β a k parameter vector
x a vector of variables
λ a scaling parameter

We also define

$$\beta'=\mu_{SP}\beta \quad (10)$$

First, data from the SP experiment is used to estimate the "scaled" beta's $\beta_k'=\mu_{SP}\beta_k$. The estimates will include the SP scale parameter, because it is not possible to separate this parameter in the estimation. Then, a composite variable C_{RP} is constructed in the RP data in the following way:

$$C_{RP}=\Sigma\beta_k' x_k \quad (11)$$

This variable is then used in the RP model estimation ($V_{RP} = \lambda C_{RP}$), yielding the estimate of the scaling factor λ. This scaling factor will then reflect the relation between the standard deviations of the error term in the SP model and the RP model.

It is also possible to estimate all parameters simultaneously. In this case however, a sequential approach was used, the main reason being that data on one variable (preferred departure time) was not available for all observations in the RP data set.

Once the parameters $\lambda\mu_{SP}\beta_k$ have been estimated we are equipped for computations of the choice probabilities p_i that apply for each passenger of the sample to each of the flight and class alternatives that have been included in the parameter estimation. Thus

$$p_i = e^{\lambda\mu_{SP}\beta' x_i} \Big/ \sum_j e^{\lambda\mu_{SP}\beta' x_j} \qquad (12)$$

These probabilities will obviously be very sensitive to the scaling factor λ; this is why it is necessary to include the bookings (revealed preferences) in the analysis. Applications will be exemplified in section 7; we now turn to the estimation procedures.

5. The stated preferences experiments

5.1 Design of the experiments

In order to estimate the parameter vector $\mu_{SP}\beta$ of the SP, it is desirable to have information on all characteristics of flight and booking class alternatives. There might exist interactions between different factors; estimating all factors and all possible interactions would imply an infeasibly huge survey, though. Therefore, a subset containing the most important factors was defined. Two "market factors" were also included in the model. Because of confidentiality we have chosen to call them "market factor 1", and "market factor 2". The following factors were included, with no interaction effects: price; service level; market factor 1; market factor 2; departure time; advance booking rule; Sunday stopover rule. "Service level" applied to international trips only, since there is only one service class on domestic flights.

The interviewee might get confused and tired, should the experiment include too many factors. Therefore, two stand alone experiments were defined. The first experiment included price, departure time and market factor 1; the second experiment included price and the remaining factors. Price was treated as a continuos variable; the other factors were given discrete design levels.

Passengers on the 6 different trip legs between airports A, B, and C were interviewed. Passengers travelling on international as well as domestic trips were included. It is important to carry out the SP in a realistic context; the interviewee should ideally have his choice preferences in his mind up front. Most of the interviews therefore were made in the departure gate, immediately prior to boarding; a few were made inflight. This implied important time restrictions on the survey, since the passengers did not have much time to answer questions during the short time they spent in the gate area.

To be able to customise the interview to the travel context of each individual, lap top PC's equipped with the MINT (Hague Consulting Group) Stated Preference interview program were used. The computer was handed to the interviewee, and the interviewee completed the interview in most cases by following the instructions given on the screen without any further assistance. The interview included questions about the preferred departure time, questions on background variables and the SP questions.

For the SP experiment, the computer presented two alternatives from the experimental design on the screen, and the respondent was asked to choose the best alternative. The respondent had the options to choose either alternative, to state indifference or to state that both alternatives were infeasible. This choice procedure was carried out 8 times for each experiment. The resulting choice data was analysed using the logit model, yielding parameter estimates for each factor and design level (price however was a continuous variable).

The interviewees were selected randomly in the gates, but as the interview took some time to complete, people arriving late would not have time to complete the interview. Two measures were taken to control this problem. The first was to minimise the length of the interview, and therefore the interview contained only one of the SP experiments (selected at random for each interview), and the interview therefore took only about 10 minutes in average. The other measure was to conduct inflight interviews for domestic trips, where passengers were selected at random in the aircraft, and thus with no regard to arrival time to the gate. The inflight sample differed from the gate sample in that interviews were not allowed in the morning peak flights. The consequence of this was that the share of direct flights was higher in the inflight sample, since passengers with connecting flights often travel earlier on the day. The distribution on other variables such as trip purpose, ticket type etc. was however quite similar.

The only statistically significant difference that was found in comparisons made between models for the inflight population and for the population selected at gates was that an earlier departure on the homebound trip had a lower value for the inflight population. Although some bias may result from the fact that people arriving late at the gate will not be able to complete their interview, it seems as if such a bias is not very serious.

The ticket price is 500 SEK LOWER than your present ticket	The ticket price is THE SAME as your present ticket
Market factor 1; design level 1	Market factor 1; design level 2
Departure time at 07.30 (1 hour prior to your preferred time)	Departure time at 08.30 (your preferred time)

Figure 2. An example of two alternatives simultaneously displayed on the screen. They can differ from the respondent's current ticket only with regard to price, market factor 1, and departure time. The respondent answers whether he would prefer the right or the left alternative for his current journey. He also can state that he is indifferent to the two alternatives, or that he considers them infeasible.

5.2 SP Results for International Trips - first experiment

The first experiment, including departure time, was divided into two different experiments, the difference consisting of different departure time levels. For final destinations outside Scandinavia (the main part), there was a departure time level defined consisting of the same time the day before/the next day (in stead of two hours earlier/later). In table 1, the parameter estimates for this group are presented. The variables and results for international and domestic trips were quite similar, so only the international trips will be represented in this paper.

The following variables are included in the model:

PRICE	the price in Swedish Crowns for an alternative
TIDFH	Number of minutes between departure and preferred departure time, departing before preferred time, homebound trip
TIDEH	Number of minutes between departure and preferred departure time, departing after preferred time, homebound trip
TIDFU	Number of minutes between departure and preferred departure time, departing before preferred time, outbound trip
TIDEU	Number of minutes between departure and preferred departure time, departing before preferred time, outbound trip
DAGF	departure 24 hours before the preferred departure time (0/1-dummy)
DAGE	departure 24 hours after the preferred departure time (0/1-dummy)

Separate models have been estimated for trips originating from each airport.

Variable	Airport A	B	C
PRICE	-0.001	-0.001	-0.002
t-value	(8.7)	(8.5)	(11.1)
Market factor 1	-0.4	-0.7	-0.6
t-value	(2.8)	(4.6)	(3.6)
Market factor 2	-0.4	-0.6	-0.8
t-value	(2.6)	(4.0)	(5.4)
TIDFH	-0.01	-0.01	-0.02
t-value	(2.5)	(3.9)	(3.2)
TIDEH	-0.01	-0.01	-0.01
t-value	(2.9)	(2.5)	(2.2)
TIDFU	-0.01	-0.01	-0.01
t-value	(2.7)	(4.9)	(3.0)
TIDEU	-0.01	-0.01	-0.01
t-value	(2.8)	(4.3)	(2.3)
DAGF	-1.5	-1.8	-1.7
t-value	(6.3)	(8.2)	(7.9)
DAGE	-1.7	-1.7	-2.1
t-value	(8.4)	(8.8)	(8.5)
L par 0	-534	-612	-578
L model	-426	-489	-403
r2	0.201	0.201	0.305
r2 const	0.200	0.201	0.304
Number obs	770	883	834

Table 1 Parameter estimates for experiment 1, international trips. The variables correspond to the $X_1 \ldots X_i$ in the logit formula and the values correspond to the estimated β'-values. The result are the estimated values to these β-values in eqn (3). It also corresponds to the X vector and $\mu_{SP}\, \beta_k$ in eqn (7).

All the β values of table 1 are negative. The corresponding relative values β'_i / β'_r are expressed in Swedish Crowns (table 2). β'_r is the parameter estimate for the PRICE variable. These relative values define a price tag for a (marginal) deviation from the preferred service. As an example, if the average passenger on his homebound trip has to depart one minute earlier than his preferred departure time, then he considers the inconvenience as bad (or good) as paying 10.- SEK more for his ticket. TIDFH/PRICE = (-0.01)/(-0.001) = 10 that is.

It should be noted that the t-values reported are (as is usually the case in SP studies) not corrected for the interdependence between observations generated by the same individual, which means that the standard deviations are underestimated and that consequently the t-values are overestimated.

Airport			
Variable	A	B	C
Market factor 1	300	400	700
Market factor 2	400	400	600
TIDFH	10	10	10
TIDEH	5	10	10
TIDFU	5	10	10
TIDEU	5	10	10
DAGF	850	1500	1800
DAGE	1050	1700	1700

Table 2 Monetary values, Crowns, experiment 1, international trips.

5.3 International trips - second Experiment

The second experiment included price, booking restrictions, and level of service; it resulted in the parameter estimates presented in table 3.

The following variables are included in the model:

PRICE	the price in Swedish Crowns for an alternative
B2DAYS	ticket must be booked 2 days before departure, return trip can be changed
B7DAYS	ticket must be booked 7 days before departure, no changes can be made
B7-14DAYS	ticket must be booked in the period of 7-14 days before departure, no changes can be made
SU-RULE	Sunday rule dummy, set to 1 if applies (otherwise not)
TOURIST	tourist class service level applies (business class otherwise)

It turned out to be necessary to merge trips originating from airport A and C in the analysis.

	Airport	
Variable	A and C	B
PRICE	-0.0009	-0.001
t-value	(11.8)	(12.1)
B2DAYS	-0.3	0.07
t-value	(2.7)	(0.7)
B7DAYS	-0.6	-0.5
t-value	(6.4)	(5.0)
B14-7DAYS	-0.8	-0.8
t-value	(8.3)	(8.2)
SU-RULE	-0.9	-1.1
t-value	(12.1)	(14.2)
TOURIST	-0.4	-0.5
t-value	(5.3)	(6.1)
L par 0	-1520	-1287
L model	-1392	-1091
r2	0.084	0.153
r2 const	0.084	0.153
Number of obs	2193	1857

Table 3 Parameter estimates for experiment 2, international trips.. The variables correspond to the $X_1 ... X_i$ in the logit formula and the values correspond to the estimated β'-values in eqn (3).

The parameter estimates correspond to the following relative values (in Swedish Crowns).

	Airport	
Variable	A and C	B
B2DAYS	333	(-70)
B7DAYS	666	500
B14-7DAYS	888	800
SU-RULE	1000	1100
TOURIST	444	500

Table 4 Monetary values, Swedish Crowns, experiment 2, international trips. (Negative values). The value within bracket is not significant at normal risk levels (see t-value in table 3).

Except for the price variable, all variables are dummy variables for each factor level in the SP experiment, excluding the reference level. For example, the 7 days advance booking restriction is valued as bad as 500 SEK for airport B compared to no advance booking restriction.

6. Models combining bookings and SP results

6.1 Data from the Booking Process

To facilitate analysis on actual choices (revealed preference, RP), SAS supplied loggings from the booking process, onto which additional information had been matched. The supplied data files thus contained information on the passenger, the chosen flight and the alternative flights.

The following numbers of observations were obtained for each of the 6 trip legs (table 5):

Trip leg	Number of observations	Undisturbed bookings
A - B	507	272
B - A	547	439
C - A	4190	2442
A - C	4181	2376
C - B	3065	1575
B - C	3036	2182

Table 5. Number of bookings in the sample for each leg, and undisturbed bookings thereof

An "undisturbed booking" occurs when a person makes a reservation and the booked class is available on all flights in the choice set. The definition is thus restricted to the choice of a flight, and does not include the choice of a class. This definition is used to classify persons who have been able to choose their preferred departure time among all scheduled flights.

6.2 Alternatives

The purpose is to model the choice of flight and booking class. Therefore, the alternatives were defined as combinations of flight and class. In principle, a trip leg with 10 flights and 7 classes would yield 70 alternatives. The booking classes are however constructed in such a way that the alternatives cannot be seen as equally available to all passengers. Some booking classes are restricted to specific categories, such as people travelling in groups, youth, retired people etc. It may well be that some persons that have actually chosen for example the C class also would qualify for say a family or group ticket, but since we do not have information on this, we have chosen to restrict alternative availability in the following way.

Chosen class	Available classes	Comments
C	C, S, M, H, K	Not category specific
S	C, S, M, H, K	Not category specific
M	C, S, M, H, K	Not category specific
G	G	Group travel
H	C, S, M, H, K	Not category specific
V	V	Only retired or youth
K	C, S, M, H, K	Not category specific

Table 6 Class alternatives, international trips

For international trips, the model will allow for choices of class and flight within all of the CSMHK classes (about 79 percent of the observations), and for choices of flight within the G and V classes respectively.

6.3 Models

An alternative in the choice model is defined as a combination of a flight and a booking class. The main characteristic of a flight is the departure time, whereas the main characteristics of a booking class (except for the fare) are the service level and the restrictions. The SP experiments provide monetary values for these characteristics (c f section 5), which means that each alternative can be assigned a monetary value $M_l = \beta'_l x_l / \beta'_r$ for each of the (discrete) variables x_l : that is departure time, service level, and restrictions. β'_r is the estimated parameter for the price variable x_r. These monetary values and the fare can be added together forming a total generalised cost $\Sigma M_l + x_r$ of each combination of flight and booking class. The sensitivity for this total cost then can be modelled based on the logged bookings, and is given by the estimated parameter for the total generalised cost. This has the purpose of obtaining the "true" market sensitivity (as opposed to the SP experiment sensitivity).

The sensitivity for the different characteristics of an alternative can depend on socio-economic variables such as gender and income, as well as on the travel context such as the trip being a business trip or a private trip. Data from the logging process contain very little of this type of information, which restricts the possibilities to consider variations in the valuations of departure time and booking class characteristics. The most efficient differentiation would probably be to separate business and private trips, but the loggings contain no efficient criteria on which such a separation can be based. The models are therefore based on the average values reported above.

One particular aspect of the problem to apply SP values to the loggings data is the valuation of departure time. This value is in principle related to a preferred departure time, which was asked for in the SP data collection, but which is not available as such in the loggings data. However, those who have made an "undisturbed" reservation are very likely to have chosen a flight which is closest to their preferred departure time. For this part of the data, there is therefore an option to assume that the departure time of the chosen flight coincides with the preferred departure time. Such an assumption affects the estimated model very much, for reasons explained below.

If the preferred departure time is assumed not to be known, the model will only differentiate between flights based on dummy variables related to whether the trip is inbound or outbound. If the preferred departure time is assumed to be known for the undisturbed bookings, the model will obtain a much higher explanatory power. The variable associated with departure time is the time difference from the preferred departure time, and since the chosen flight always will have the lowest time difference (i.e., zero), then the model will improve substantially in terms of log likelihood. In fact, if one would try to estimate a separate parameter for the time difference, it would tend to go to infinity. This is because the likelihood of the observed choices (which is maximised in the maximum likelihood estimation procedure) will increase as the parameter for the time difference increases, because the parameter is defined only for observations where it increases the probability of the chosen

alternative. To be able to estimate such a parameter, we would have to include observations for which the chosen flight does not have the smallest time difference.
The way in which the information on the preferred departure time is included in the models presented here is by assigning the same parameter to the value of time differences as to the value of other characteristics. The cost parameter will then be higher than in the case where we assume no information on the preferred departure time, but it will not go to infinity because of the fact that the cost parameter also affects the booking class choices. The estimated parameter value will - as always when maximum likelihood techniques are applied - be the one that maximises the likelihood of the observed choices of flight and booking class.

The two models - without and with the assumption on preferred departure time information - thus represent two extremes related to the model we would have obtained if we had had information on the preferred departure time for all observations.

In the table 7 below, the cost parameters for each trip leg is presented for both models:

Variable	AB		BA	
	Model 1	Model 2	Model 1	Model 2
Cost	-0.0006	-0.005	-0.001	-0.007
t-value	1.9	13.3	4.2	10.8

Variable	BC		CB	
	Model 1	Model 2	Model 1	Model 2
Cost	-0.007	-0.01	-0.007	-0.01
t-value	13.8	25.7	15.7	34.7

Table 7 *The estimated cost parameters and their t-values for each trip leg for both models. These cost parameters correspond to $\lambda\mu_{SP}\beta_r$, where r is the index of the price variable, in eqn (9).*

7. Application

7.1 Method

Since $\lambda\mu_{SP}\beta_k$ now has been estimated, it is possible to compute choice probabilities p_i in simulated situations using the equation

$$p_i = e^{\lambda\mu_{SP}\beta x_i} / \sum_j e^{\lambda\mu_{SP}\beta x_j} \qquad (12)$$

It is for example possible to simulate the effect of decreasing the fare (price) on one particular booking class on all flights between two of the airports. If the value of the price variable x_r is changed, then (6) will allow computation of all the choice probabilities in this simulated situation. The implied change in the total revenue derived from the passengers in the sample also could be computed. Practical aspects of such pricing analyses have not been studied in the present project, though.

Another possibility is to restrict the choice set, in order to find out where the rejected bookings would end up. This was the main purpose of the project, and some examples will be given. The parameters $\lambda\mu_{SP}\beta_k$ were estimated using the restricted choice set actually facing each passenger. In the sample used for estimation, one could for example simulate that the H class is unavailable (closed) on all flights from A to C. Some of the choice probabilities then are changed (often increased) which makes it possible to compute buyup. The model will predict the effect, which differs depending on what model is being used. If the model with no information on the preferred departure time is used, many passengers are assumed to transfer to other flights. If the other model is used, this effect is much smaller. The effect in terms of buyup does not differ very much though.

7.1 Buyup Effects Example

Buyup is defined as the percentage of persons that try to book on a higher class if rejected at a lower class. The substitution allowed for in the present model is restricted to class and flight choice. If the lowest class is set to be unavailable for all persons, then the market shares previously allocated to this class will be redistributed to other (higher) classes. Thus, a buyup of 100 percent will be achieved.

If the lowest class is set to be unavailable for a specific flight only, then the model will again redistribute the previous demand to other (higher) classes, but now also to other flights in the same (lowest) class. In this case, not only buyup but also recapture will be modelled. The extent to which recapture will take place is depending on the sensitivity to departure time. The current model has two versions - one which not uses the estimated values of departing earlier and later than the preferred departure time from the SP experiment, and one that does use this information. The latter version will, of course, exhibit a lower recapture ratio and thus a higher buyup ratio.

Example 1: If a flight has about 40 passengers in the H class between C and A, as a total over the 2 week logging period. If the H class passengers were rejected on this flight, the version one model would predict 23 passengers to choose higher classes - a buyup of 60 percent. The version two model would predict 28 passengers to choose a higher class - a buyup of 70 percent.

The possibility of deviation is however not included in the model. Deviation means that the rejected person will not buy a ticket at all, implying that the person either will choose another airline (i.e. a competitor to SAS), another mode, or that he will cancel the trip. In the last case, a trip to another destination may be an additional option that may be identified as a kind of recapture if he chooses the same airline.

On the C-A market, there is also another airline. A course estimate of the deviation to the competitor can be made based on the market share of the other airline. If the market share of the other airline is one third, and if the structure of flights, classes and demand is reasonably similar to the SAS case, then about one third of the rejected passengers in the closed class will divert to alternatives of the other airline (in the model).

Example 2: Of the 40 rejected passengers in the H class of the xyz flight, now one third - 13 passengers - would choose to go by the other airline. Of the remaining 26 passengers, 60 *percent or 16 passengers would still choose a higher class - the buyup would now be 16/40 or 40 percent. Similarly, the version two model would now give a 45 percent buyup.*

To model deviation to other modes, a mode choice model is needed. This would allow the deviation to other modes to be modelled. Also here, market shares would say something about the redistribution of rejected bookings, but the degree of substitution may well be lower between modes than between flights and classes.

The substitution of the rejected class with other alternatives depends on the market shares for the different alternatives, and on the degree of substitution that is defined by the similarity of the class/flight alternatives and other alternatives (defined by a logsum parameter in a structured logit model). If the alternatives were perceived as equally similar, and the logsum parameter therefore would be equal to one, then the market shares would reveal most of the effects of the redistribution of the rejected class. As an example, if the air market share is 20 percent, then deviation to other modes would account for 80 percent of the redistribution.

Example 3: If the market share is 50 percent for air in the C-A case, deviation to other modes would be 20 passengers of the rejected H class passengers of the flight in question. Of the remaining, one third (7 passengers) would turn to the other airline, and of the remaining 13 passengers, 8 would choose to book a higher class. This brings the buyup ratio to 20 percent for model one, and to 22.5 percent for model two.

It is important to point out that the market shares relate to the individual, and not to the average across the market. The model thus takes into account the alternative availability for each individual separately. It is important to distinguish different market segments, if they differ by distribution on market shares. For example, if the H class passengers belong to a market segment with a lower air market share, then the deviation would be higher for this segment, and the buyup would consequently be lower.

Example 4: If the market share is 20 percent for H class passenger for air in the C-A case, deviation to other modes would be 32 passengers of the rejected H class passengers of the flight in question. Of the remaining, one third (3 passengers) would turn to the other airline, and of the remaining 5 passengers, 3 would choose to book a higher class. This brings the buyup ratio to 7 percent for model one, and to 8 percent for model two.

Therefore, since the buyup ratio may be heavily dependent on the possibilities of substitution outside the flight/class alternatives, it seems highly desirable to develop the model to include these other options.

8. Conclusion and further research

The main conclusion is that the study shows that the modelling concept works. Considerable experience of this modelling task has been gained, and can be used for further studies. It must however be borne in mind, that complexities such as connection flights has not been dealt with, and that the deviation issue also not has been analysed.

The SP analyses show considerable differences in behaviour between private and business trips. There may also be other ways to define different market segments. It is therefore desirable to be able to consider different market segments in the models. A problem is how these market segment can be identified by the information obtained during the booking process.

Recently, a technique for endogenously identifying market segments, where the segment membership is a latent variable, has been applied to travel demand analysis [2,4]. In such an approach, the model contains a probabilistic segment membership model, and separate choice models are then estimated for each segment. The segment probability is defined by a number of variables related to the individual and to the trip. It may well be worth while to test this technique to make the most out of the information actually made available during the booking process.

Due to the lack of information on preferred departure time in the booking data, it was not possible to estimate a structured model using the SP information. However, it is possible to assign the available alternatives onto the SP-data for the days on which booking data and SP interviews were carried out simultaneously. Using such a subset, it may well show feasible to obtain a model that fully combines RP and SP information for each individual.

Another aspect is the systematic differences between the days in the week. To be able to predict choices for each day separately, it would be possible to develop a model that explicitly models each of the seven days in the week. In such a model, it would be possible to estimate the effects of closing a class on Tuesdays only, as an example.

These aspects can be analysed using the current data sets. A problem that requires additional data concerns connection flights, which are currently not included.

It also seems highly desirable to include other possibilities of substitution such as other airlines and other modes into the model, since the buyup ratio is heavily depending on the deviation ratio. This can be achieved by the development of choice models containing all modes related to long distance travel, integrated with time and class models for scheduled modes.

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DRAFT
PROGRAMME

THE ASIA PACIFIC TRANSPORT CONFERENCE

June 27, 1997

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Prepared for discussion at the business meeting of the ATRG conference

To the International Advisory Group of the PECC Transportation Task Force and other interested colleagues: The following is the very rough draft programme of the Asia Pacific Transport Conference jointly held by the Korea Transport Institute and Taipei PECC in Singapore on November 14 (Friday), 1997.

Aims of the Pacific Economic Cooperation Council (PECC)

The PECC has been privately organized to help the successful implementation of the regional cooperation of the APEC member economies. The members are academia and professionals of the private sectors. They help to identify the problems of the region and suggest solutions to them through research and policy advices. The PECC Transportation Task Force is doing the same thing in the transportation sector of the region as a counterpart to the Transportation Working Group (TWG) of the APEC.

Aims of the Asia Pacific Transport Conference (APTC)

There was a conference such as the APTC in Singapore in 1995, which was cosponsored by Australian, Chilean, Korean and Singaporean PECCs. It dealt with the subject of challenges and obstacles the region faces in continued economic development and opportunities several reforms will provide to the region in the transportation sector. It is recognized that the countries in the region are suffering from regulation, internal as well as international. Also the shortages in transport facilities are notes as a hurdle to smooth accommodation of growing transport demand. Regulatory reforms and transborder transport liberalization were suggested. In addition, some methods are provided for the liberalization.

The APTC is in the continuation of the first conference mentioned above. Despite the fact that liberalization will contribute to efficient use of resources and to enlargement of market size, and thus to the smooth economic growth, there are still concerns, with reason, among many countries that most of the benefits coming out of the liberalization will be accrued to the advanced economies with powerful, competitive megacarriers. Some national carriers may be damaged due to their poor networks, meager national traffic and weak cost competitiveness, etc.. On the part of the users of transport services, liberalization may generally lead to the improvement in welfare of passengers and shippers. Even in this part, however, some concern may be raised that although the operation of megacarriers are efficient, their operation may not be stable in that they may retreat from particular markets at any time if economic condition surrounding them is not favorable relative to some other markets. Also as in the case of domestic markets, some dominant carriers survive in competition to raise anticompetitive barriers to entry, and to utilize dominant power in fare setting and in providing services. This will surely reduce the welfare of the users contrary to what is expected from the transborder transport liberalization. Therefore it is very much necessary for the successful implementation of the multilateral liberalization to examine carefully the economic effects of transborder transport liberalization.

On the basis of the above arguments, the APTC is going to review the experiences of transborder liberalization in the light of total welfare as well as compositional welfare of passengers, shippers and carriers by country concerned. Also some institutional arrangements are considered that will help to get around the problems in benefit distribution and in monopoly power due to liberalization.

The Conference Programme

Opening Session

Overview of Transborder Transport Liberalization : Experiences and Challenges

Session 1. Transborder Transport Liberalization : Experiences (history, Institutional arrangements, rough outcomes)

- Individual Liberalization (US)
- Bilateral Liberalization (US/Canada)
- Multilateral Liberalization (EU, ASEAN)

roundtable discussions

Session 2. Transborder Transport Liberalization : Economic Effects

- Individual Liberalization
- Bilateral Liberalization
- Multilateral Liberalization

roundtable discussions

Session 3. Transborder Transport Liberalization : Prospective Problems and Concerns

- Problems with liberalization process
- Problems with economic effects of liberalized markets
- Concerns with liberalization

roundtable discussions

Session 4. Institutional Arrangements to Overcome Problems and Concerns

Closing Session

Concluding Remarks (by Prof. Tae H. Oum)

Conference Venue

- The APTC will be held on November 14 (Friday), 1997, at the Mandarine Hotel on Orchard Road of Singapore. The Chartered Institute of Transport Singapore will be holding 3 days seminar called "The Transportation and Logistics Conference" at the same place until November 13, 1997. Some sharing of participants is possible to both conferences.

Discussions

- Suitability of the theme and programme of the APTC
- Recommendation of speakers and range of participants

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Dr. Brent D. Bowen is Director and Professor, Aviation Institute, University of Nebraska at Omaha. He has been appointed as a Graduate Faculty Fellow of the University of Nebraska System-wide Graduate College. Bowen attained his Doctorate in Higher Education and Aviation from Oklahoma State University and a Master of Business Administration degree from Oklahoma City University. His Federal Aviation Administration certifications include Airline Transport Pilot, Certified Flight Instructor, Advanced-Instrument Ground Instructor, Aviation Safety Counselor, and Aerospace Education Counselor. Dr. Bowen's research on the development of the national Airline Quality Rating is regularly featured on *ABC's Good Morning America, The Cable News Network, USA Today, The Today Show, The Associated Press,* the network evening news shows, and in numerous other national and international media, as well as refereed academic publications. Dr. Bowen has in excess of 200 publications, papers, and program appearances to his credit. His research interests focus on aviation applications of public productivity enhancement and marketing in the areas of service quality evaluation, forecasting, and student recruitment in collegiate aviation programs. He is also well published in areas related to effective teaching. His professional affiliations include the University Aviation Association, Council on Aviation Accreditation, World Aerospace Education Association, Alpha Eta Rho International Aviation Fraternity, and the Nebraska Academy of Sciences. Additionally, Dr. Bowen has authored /co-authored numerous successful funding proposals totaling in awards exceeding nine million dollars. He also serves as program director of the National Aeronautics and Space Administration funded Nebraska Space Grant Consortium.

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