ANALYSIS OF THE DOMESTIC AIR PASSENGER DEMAND IN JAPAN

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1. Introduction

Japanese government has to authorize the next long term Master-Plan of Airports by 1986, for which the uncertainty of the future demand is a serious problem. Overestimation for the future demand of the last Master-Plan being clear as to these three years, we started this research, the objectives of which are the analysis of the time-series data and renewal of forecast models. This study is divided into four parts as follows. 1) Analysis of the impacts on air travel demand in terms of railway and airline fare rate, beginning of jet liner services, airplane accidents and the setting-up of Shinkansen railways services. 2) Modeling of the modal split for three types inter-city travels taking aggregate and disaggregate approaches. 3) Future demand forecast. 4) The feasibility analysis of commuter air service. These results of analysis are essential for the airports planning.

2. Transition of air demand

In general, domestic air demand in Japan has been increasing rapidly to date. The factors of this increase can be summarized as follows. 1) Increase of overall transportation demand supported by economic growth. 2) Rise of the share of air transportation due to heightening standard of the needs of people. 3) Rise of transportation capacity and improvement of service by the introduction of larger aircraft and development of airport. 4) Rapid rise of JNR (Japan National Railways) fare.

In the period of general increase of air demand the declines of annual demand were reported only three times, 1966, 1980, 1982, (Fig. 1). The

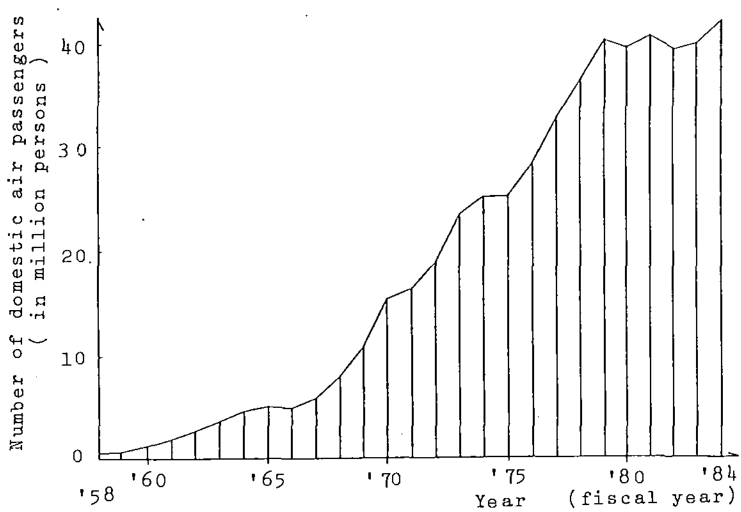

Fig-1 Number of Domestic Air Passengers

first decline was caused by the four successive airplane accidents and the opening of Shinkansen-express service. The second was due to the prevailing recession caused by the second Oil-shock, and was due to rise in air fares by average 23.9%. The third was caused by the rise of fare by 13.5%, the accident off the coast Haneda, and the beginning of Tohoku-Shinkansen and Joetsu-Shinkansen services.

After 1980, as shown in Fig. 1, the air demand behaved in some different manner from that before the year. We have to cope with this change of the manner of demand effectively to make correct estimation of the demand.

3. Analysis on the factors of Air Demand

In this chapter, we list the factors of air demand and analyze on the factors. The analysis is how much the factors give their effects on the demand, whether the effects differ among the routes and how long the factors retain their effects on the demand.

We list 5 factors which can be analyzed quantitatively 1) rises in air fares 2) airplane accidents 3) introduction of jet liners 4) entrance of competitors 5) ups and downs of business.

(1) The effect of rise in air fares.

The cases we analyzed are the 2 of rise in air fares (23.8% in March 1980, 13.5% in January 1982) and a rise in JNR fares (50.4% in November 1976). We calculated the elasticity and the cross-elasticity of the demand against the rises in fares 6 months or 12 months before. The calculation was done about each group shown in Table 1. The groups are set among 22 routes which are ranked higher than 30th. by the number of passengers (achievements in 1981) and are little influenced by the introduction of jet liners.

The results of analysis are shown in Table 2 and Table 3. From these results, we can say as follows.

<The effect of rise in air fares>

(i) Group E and F which are of long range and across the sea have undergone a slight decline of demands compared with other groups, while Group A and B which have Shinkansen express as their competitor have undergone relatively large decline of demands.

(ii) As far as Group A to Group D which have each kind of competitors are concerned, the rises of air fare (by 10%-20%) retain its effect for more than a year though weakening.

<The effect of rise in JNR fares>

(i) The air demand rises fairly well as the JNR fares rise, with the exception of Group D (Osaka-Shikoku island) which has high load-factor.

(ii) The effect continued for more than a year probably due to large percentage (50.4%) of the rise.

Table-1 Grouping A-F

group	route	group	route	group	route
A	Tokyo-Osaka Tokyo-Fukuoka Oosaka-Fukuoka	C	Tokyo-Matuyama Tokyo-Nagasaki Tokyo-Kumamoto Tokyo-Ooita Tokyo-Miyazaki Tokyo-Kagoshima	E	Tokyo-Sapporo Tokyo-Hakodate Oosaka-Sapporo
B	Oosaka-Nagasaki Oosaka-Kumamoto Oosaka-Ooita Oosaka-Miyazaki Oosaka-Kagoshima Fukuoka-Miyazaki Fukuoka-Kagoshima	D	Oosaka-Matuyama Oosaka-Koochi Oosaka-Tokushima	F	Tokyo-Okinawa Oosaka-Okinawa Fukuoka-Okinawa

Table-2 The Effect of Rise in Air Fares

group	6months	12months
A	-o.661	-o.475
B	-o.553	-o.469
C	-o.494	-o.3o5
D	-o.169	-o.254
E	o.oo5	o.o44
F	o.135	o.171

Table-3 The Effect of Ries in JNR Fares

group	6months	12months
A	0.421	o.426
B	o.297	o.294
C	o.355	o.47o
D	o.o83	o.164
E	o.217	o.37o

(2) The effect of airplane accidents

We analyzed the effect of airplane accidents quantitatively by comparing air demand with that of the same month in the preceding year. 2 cases are analyzed. The one happened in the sky of Shizukuishi town Iwate prefecture in July, 1971 (162 dead) and the other happened off the coast of Haneda in February, 1982 (24 dead)

Figure 2 shows a result of the analysis on the Shizukuishi case. From the figure, we can say that the effect of the accident almost disappeared after a year, and we have got the same result from the analysis on the Haneda case.

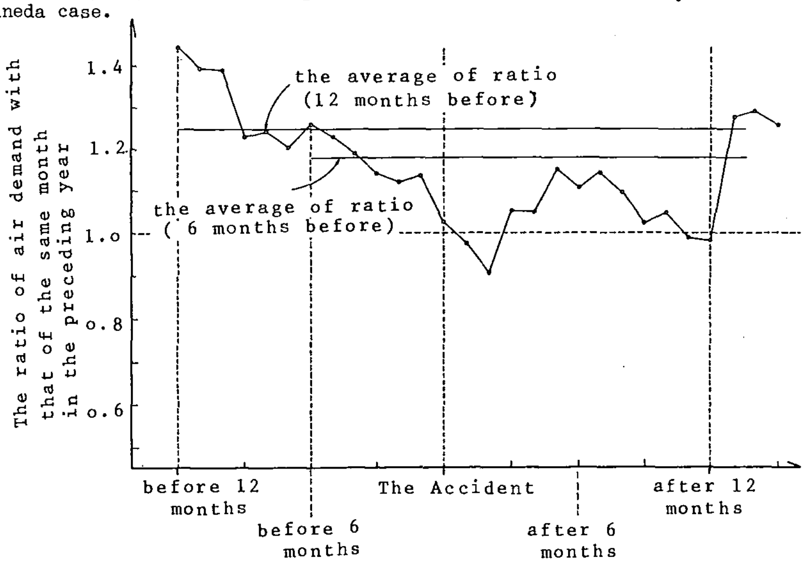

Fig-2 The Effect of Airplane Accident in July 1971

(3) The effect of introduction of jet liners

We analyzed the route Osaka-Nagasaki with Nagasaki Airport which came to accept jet planes in May, 1980 and the route Tokyo-Akita with Akita Airport which came to accept jet planes in June, 1981. In addition, we recognize the time of each route's completion of introducing jet liners as the time when the yearly average number of passengers by air liner exceeded 150 which is the seat capacity of YS11 (preceding propeller liner). Table 4 shows the demand for the routes above after and before the introduction of jet liners. From the table, we can say that the introduction of jet liners provided the route Osaka-Nagasaki and the route Tokyo-Akita with 170% and 290% of each pre-jet demand.

Table-4 The Effect of Introduction of Jet Liners

route	(1) before the introduction of jetliner	(2) after the introduction of jetliner	(1)/(2)
Oosaka-Nagasaki	321,649	546,215	1.7o
Tokyo -Akita	172,6o5	5o7,887	2.94

(4) The effect of the extension of Shinkansen service.

We analyzed the effect of the opening of Sanyo-Shinkansen service March 10, 1980 from Okayama to Hakata by observing time series transition of the demand of air route Osaka-Fukuoka and of JNR.

Figure 3 shows the result of the observation. On the figure, the share of air against JNR seems to go down drastically at first, but in a stability, it keeps 15% less percentage than before the opening of Sanyo-Shinkansen.

About the route Tokyo-Fukuoka, the change of shares is temporary and the recovery was completed after 3 years. From the Tokyo-Fukuoka case, we can say that the extension of Shinkansen service produced weaker effect on the longer range transportation.

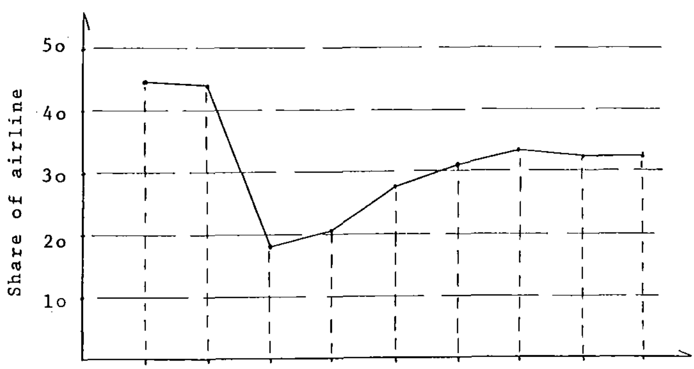

Fig.3 The effect of The Extension of Shinkansen Service

(5) Principal indices of economics and the fluctuation of demand.

Figure 4 shows the relation between net GNP and air demand. Though, in general, the two are in proportional relation, they come out of the proportionality after the first Oil-shock of 1974 and especially after 1980. Therefore, we should be careful when we introduce the indices of economics into demand forecasting models.

About the other indices such as of the production of whole industry, of the production of manufactural industry and of per capita disposable income, there could not be found any proportionality between each of them and air demand after 1980. And this loss of proportionality is more obvious in western countries.

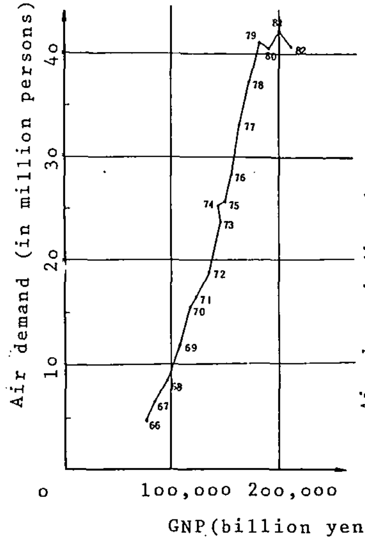

Fig-4-a GNP and Air Demand in Japan

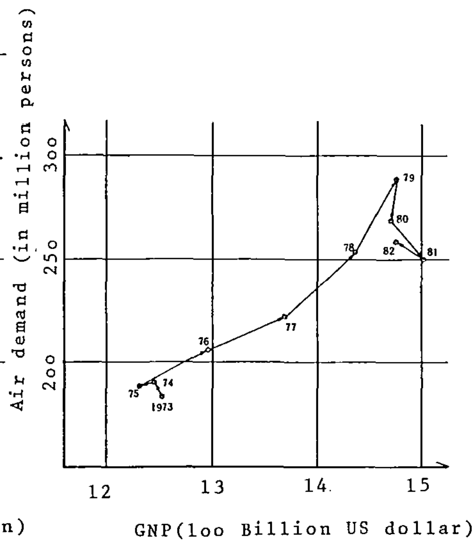

Fig-4-b GNP and Air Demand in U.S.A.

4. Analysis on the Domestic Air Passenger Demand in Japan

(1) Outlines of the models built.

The existing models by MOT (Ministry of Transport in Japan) are restricted to macro-economic ones or those concerning only with the trend in the total volumes of transportation.

In this paper, we have built the models with more structural action by which the changes of various transportation policies such as fare, routes nominal speeds, capacities of equipments, accessibilities to airports, and the competition with other transportation services are reflected in the forecast.

Three types of models are built. The structures of them are as follows.

Model I $\quad Dij = Tij \times Pij$ .... (I)

where

Dij = Air Passenger Demand origin i to destination j[person/year]

Tij = Air and Rail Passenger Demand origin i to destination j [person/year]

Pij = Market Share of Air Passenger Demand origin i to destination j

$$Tij = K \prod_{k=1}^{l} X_{k_{ij}}^{\alpha_k} \quad \text{...} \quad \text{(I)-a.}$$

where

X_1 = (GDP)i × (GDP)j [(billion yen)^2]

X_2 = Distance of Air Route i,j [kilometer]

X_3 = Jet-Planes service or not...Dummy variable

jet-plane service X = e

not jet-planes service X = 1

K = constant

α_k= parameter for X_k

$$pij = \frac{1}{1+EXP\{\sum_{k=1}^{m}\alpha_k \times X_{kij}+\beta\}} \qquad \text{(I)-b.}$$

where
X_1 = Airline Fare between i and j [100yen]
X_2 = Railway Fare between i and j [100yen]
X_3 = Linehaul Time on Airline between i and j [minute]
X_4 = Access and Egress Time to Airport [minute]
X_5 = Linehaul Time on Railway between i and j [minute]
B = constant
α_k = parameter for X_k

Model II $$Dij = K \prod_{k=1}^{n} X_{kij}^{\alpha_k} \qquad \text{(II)}$$

where
Dij = Air Passenger Demand origin i to destination j [person/year]
X_1 = (GDP)i × (GDP)j [(million yen)^2]
X_2 = Distance of Air Route i,j [kilometer]
X_3 = Jet-Planes service or not ...Dummy variable
X_4 = Airline Fare between i and j [100yen]
X_5 = Railway Fare between i and j [100 yen]
X_6 = Linehaul Tome on Airline between i and j [minute]
X_7 = Access and Egress Time to Airport [minute]
X_8 = Linehaul Time on Railway between i and j [minute]
K = constant
α_k = parameter for X_k

Model III.

A model by the EPA method of analyzing time series data sets, (EPA: Economic Planning Agency) With this method, various kinds of changes, observed in overall air demand, such as trends, cyclical fluctuations, seasonal or irregular variations can be distinguished from each other.

(2) DATA

The demand models have been calibrated based upon a sample of 48 domestic airlines for nine years (1972-1981). The 48 domestic airlines were divided into 8 groups by each airline's characteristics (Table 5). Figure 5 shows the shares of the Japanese National Railways (JNR) and airlines as classified by range of hours required by JNR trains.

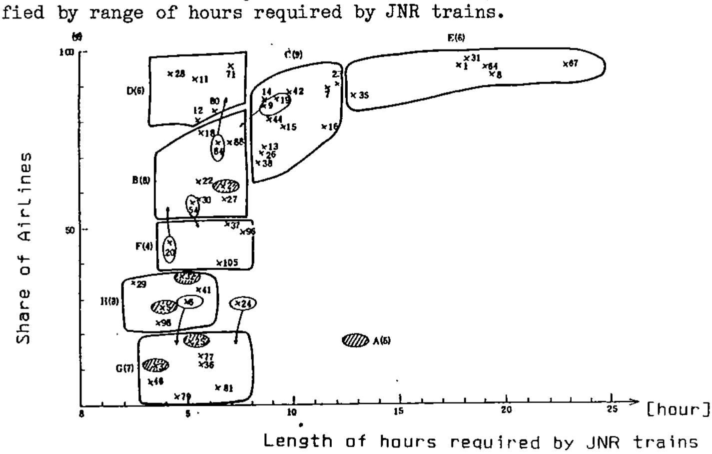

Fig.5 Share of JNR and Airlines -1982-

Table-5 8 Groups of Domestic Airlines

GROUP	ROUTE
A	TOKYO - FUKUOKA
	TOKYO - OSAKA
	OSAKA - FUKUOKA
	TOKYO - HIROSHIMA
	NAGOYA - FUKUOKA
B	OSAKA - KAGOSHIMA
	OSAKA - KUMAMOTO
	OSAKA - MIYAZAKI
	OSAKA - NAGASAKI
	OSAKA - OITA
	FUKUOKA - KAGOSHIMA
	FUKUOKA - MIYAZAKI
	NAGASAKI - KAGOSHIMA
C	TOKYO - MATSUYAMA
	TOKYO - KOCHI
	TOKYO - TOKUSHIMA
	TOKYO - KAGOSHIMA
	TOKYO - KUMAMOTO
	TOKYO - NAGASAKI
	TOKYO - MIYAZAKI
	TOKYO - OITA
	NAGOYA - KAGOSHIMA
D	OSAKA - KOCHI
	OSAKA - MATSUYAMA
	OSAKA - TOKUSHIMA
	NAGOYA - KOCHI
	NAGOYA - MATSUYAMA
	FUKUOKA - MATSUYAMA
E	TOKYO - CHITOSE
	OSAKA - CHITOSE
	FUKUOKA - CHITOSE
	CHITOSE - NAGOYA
	CHITOSE - KOMATSU
	CHITOSE - SENDAI
F	OSAKA - SENDAI
	NAGOYA - SENDAI
	KOMATSU - FUKUOKA
	HIROSHIMA - KAGOSHIMA
G	TOKYO - SENDAI
	TOKYO - HANAMAKI
	TOKYO - AOMORI
	TOKYO - KOMATSU
	TOKYO - AKITA
	TOKYO - YAMAGATA
	TOKYO - TOYAMA
H	OSAKA - TAKAMATSU
	TOKYO - TAKAMATSU
	TAKAMATSU - FUKUOKA

(3) About the G.D.P. (Gross Domestic Product) as a variable

In order to know what is the best way to introduce G.D.P. to the models, 6 models were calibrated using 401 observations (about 48 domestic routes). The results are shown in Table 6. The models in Table 6 have following two types of GDP variables

type A. (GDP)i × (GDP)j....model 1,3,5
type B. (GDP)i + (GDP)j....model 2,4,6

In the table, all models in type A give higher multiple correlations than those in type B. So we can say that the multiplicational form (type A) is better than addition form (type B)

In the following analysis, model 1 in type A is adopted because of the highest multiple correlation.

Table-6 GDP in the Model 401 CASES (t-value)

VARIAB. | MODEL	1	2	3	4	5	6
AIRCOST [YEN]	-0.728 (-5.24)	-0.379 (-2.39)	-1.378 (-9.70)	-1.288 (-8.32)	-0.778 (-2.72)	-0.748 (-2.33)
RAILCOST [YEN]	0.420 (2.98)	0.466 (3.02)	0.321 (2.25)	0.333 (2.13)	0.412 (2.81)	0.408 (2.54)
JET SERVICE *1 (DUMMY VARIABLE)	1.336 (14.36)	1.767 (16.23)	1.294 (13.81)	1.662 (15.61)	1.333 (14.10)	1.731 (15.44)
(GDP)i*(GDP)j *2 /DIST.	0.666 (15.85)					
((GDP)i+(GDP)j) /DIST.		0.927 (11.91)				
(GDP)i*(GDP)j			0.617 (15.56)		0.664 (15.10)	
(GDP)i+(GDP)j				0.822 (11.80)		0.900 (11.18)
DISTANCE [KILOMETERS]					-0.616 (-2.41)	-0.557 (1.92)
CONSTANT	7.077 (6.58)	7.125 (5.77)	10.720 (10.74)	12.090 (11.23)	7.345 (4.28)	9.054 (4.74)
R *3	0.737	0.671	0.733	0.669	0.736	0.671

*1 JET SERVICE LINE=1 : OTHERS=0

*2 GDP (BILLION YEN)

*3 MULTIPLE CORRELATION

(4) Model Estimated

Table-7 shows the model parameters estimated for All (air and rail) Passenger Demand (Model I-a). Similarly Table-8 shows parameters of the Market Share Model (Model I-b), Table 9 shows that for Air Passenger Demand (Model II).

Table-7 All Passenger Demand Model

groups	No of data	X_1	X_2	X_3	K	R_D
A	45	1.11 (21.94)	−0.77 (−4.65)		2.55×10^{-1} (−0.86)	0.951
B	71	0.74 (6.55)	−0.91 (−3.57)		7.95×10^{2} (6.74)	0.441
C	80	0.61 (12.00)		1.04 (16.70	3.53×10^{0} (1.40)	0.895
D I	27			0.29 (2.27)	6.73×10^{5} (184.8)	0.380
D II	21	0.70 (3.39)			1.08×10^{0} (0.02)	0.673
E	49	1.22 (35.82)	−2.95 (−20.42)		7.84×10^{4} (12.08)	0.961
F	18	0.66 (11.70)	−0.43 (−2.76)		4.20×10^{1} (4.82)	0.959
G	63		−0.54 (−2.20)	0.55 (6.41)	5.65×10^{7} (11.44)	0.784
H	27	1.16 (12.44)	−1.41 (−13.11)		4.92×10^{0} (1.17)	0.886

( ) ; t-value
R ; multiple correlation

Table-8 Market Share Model

groups	No of data	X_1	X_2	X_3	X_4	X_5	Const	R_s
A	50		−2.62 (−8.67)	2.29 (8.21)	2.91 (3.06)	−0.62 (−10.07)	−10.46 (−0.11)	0.908
B	79		−3.55 (−19.65)	3.59 (9.98)		−0.36 (−10.56)	140.94 (8.04)	0.927
C	89		−3.60 (−12.93)	3.54 (7.85)			−24.00 (−0.49)	0.856
D	54	5.07 (11.66)	−4.80 (−9.64)				−223.90 (−8.21)	0.870
E	54	2.28 (7.15)	−2.24 (−7.21)		0.97 (2.69)	−0.44 (−4.32)	−125.90 (−1.84)	0.857
F	22			1.61 (3.56)			−137.87 (−3.51)	0.613
G	70	1.52 (4.34)	−5.06 (−14.92)	4.01 (10.03)	0.66 (2.49)	−0.36 (−4.83)	107.88 (2.39)	0.914
H	30		−2.68 (−4.94)	2.85 (7.15)			45.75 (2.58)	0.780

( ) ; t-value
R ; multiple correlation

Table-9 Air Passenger Demand Model

groups	No. of data	X_1	X_2	X_3	X_4	X_5	X_6	K	R_{DA}
A	45			−0.22 (−2.42)	0.77 (7.00)	0.37 (1.83)	1.20 (15.11)	2.04×10^{-2} (−3.34)	0.921
B	71				0.35 (4.71)	0.93 (4.43)	0.85 (12.72)	3.01×10^{0} (1.25)	0.770
C	80			−0.36 (−3.94)	0.38 (2.15)	1.97 (14.48)	0.62 (5.76)	1.42×10^{2} (2.67)	0.763
D	48	−3.20 (−9.30)					1.07 (3.47)	8.06×10^{9} (4.38)	0.526
E	49			−0.89 (−5.08)			1.18 (19.95)	2.33×10^{3} (4.23)	0.927
F	18			−0.32 (−0.48)	0.78 (0.74)	0.27 (0.60)	0.34 (1.52)	5.17×10^{2} (1.48)	0.636
G	63	−0.90 (−2.17)	0.81 (3.83)			1.07 (6.48)	0.85 (3.88)	1.36×10^{1} (0.48)	0.780
H	27			−0.49 (−4.10)			0.92 (6.23)	1.92×10^{2} (2.28)	0.822

( ) ; t-value
R ; multiple correlation

Demand for the routes of group A estimated with the model I, II, III are shown in Fig. 6. From the figure, we can say as follows.

(i) The estimation with the model II reflects the decline of demand observed after 1980 more directly than that with the model I which is also structural.

(ii) Model I gives underestimation for the demand during the period 1974-1976, while it gives overestimation for the demand after 1980.

(iii) The estimation with the model III which is of single regression does not reflect the decline of the demand after 1980.

The models' behaviour like above appears not only in group A but also in other groups.

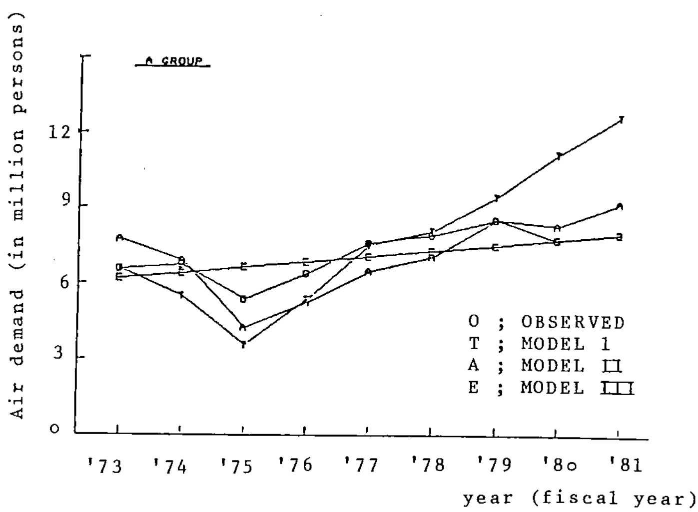

Fig-6 Estimated Demand of A Group

In addition to 48 domestic main routes, Model II and Model III for 5 routes to remote islands, and Model III for remaining routes were estimated. Using these models the total domestic air passenger demand of 167 routes were predicted. Figure 7 shows the procedure of demand forecasting.

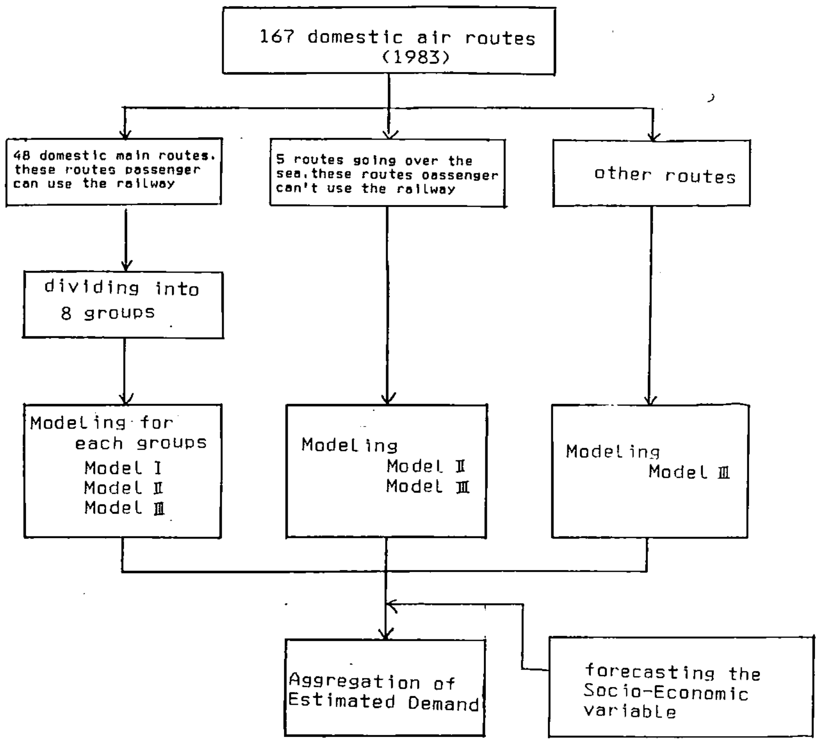

Fig. 7 Block Diagram of Demand Forecasting

For the aggregation of estimated demand with each model next three alternative combinations A,B,C are used.

Figure 8 shows the annual demand observed and the one estimated with the models in the combinations of A,B,C in table. From the figure we can say as follows.

(i) Comparing the combination B with A, we found the former reflects observed decline of demand in 1980 more exactly than the latter.
(ii) Combination A gives overestimations before 1976 and underestimations after 1980, though giving very correct estimation during 1977-1979.
(iii) Combination C can't give the decline of demand after 1980 to the estimation by it. And this is probably because the model III, which is the only component of combination C, is of single regression lacking structural behaviour.

	48 routes (8 groups)	5 routes over the sea	other routes
Conbination A	Model I	Model II	Model III
Conbination B	Model II	Model II	Model III
Conbination C	Model III	Model III	Model III

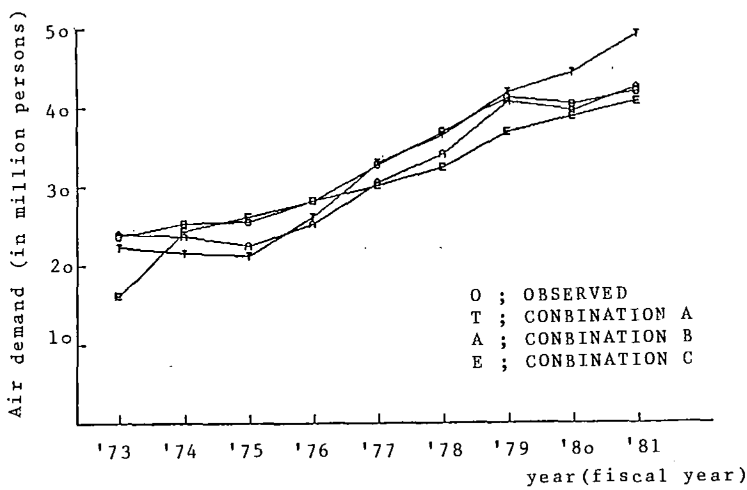

Fig-8 Total Demand of Estimation

5. Forecasting the Air Demand of 1990

Using the combinations A, B and C, we forecasted sum of all domestic air demand of 1990 at when the master plan of airports by Japanese governmental authority is aimed.

We assumed that GDP, which is one of the variables introduced to the models, will rise 4% annually taking the speed of economic growth into account, the elasticities of demand against GDP is calculated and shown in Table 10.

Table 11 shows observed elasticity of demand against GDP.

From these tables, we can say that the averages of elasticities based upon models (both of model I-a and Model II) are both almost the same as observed one. But we should be careful about the fluctuation of observed elasticities in Table 11.

Figure 9 shows the results of forecasting. Demand in 1990 is forecasted 71,280,000 with the combination A, 71,110,000 with the combination B, and 58,750,000 with the combination C.

Each forecasted demand with combination A and B corresponds to those forecasted under the assumption that the demand increases about 8% annually.

The reason of overestimation with the combination A and B is that the models used are not based upon the data of the period after 1980 containing the period of declining demand but upon those from 1973 to 1981.

Here, we revise our demand forecast for the group A. When we pay attention to the relation between the transition of G.D.P. and that of demand for group A, we find that the demand for group A is much more influenced by the variation of G.D.P. than other groups. So, we guess that the demand for group A was forecasted too large.

Table-10 GDP Elasticity

-estimated-

GROUP	ELASTICITY (AS TO GDP)	
	MODEL I a)	MODEL II
A	2.23	2.42
B	1.48	1.71
C	1.22	1.24
D	——— *	2.15
E	2.46	2.37
F	1.32	0.68
G	——— *	1.71
H	2.34	1.85
remoted	——— *	2.19
AVE.	1.84	1.81

* Model with GDP variable was not built.

Table-11 GDP Elasticity

-observed-

YEAR	ELASTICITY (OBSERVED)
1973	1.79
1974	——— *
1975	0.51
1976	2.05
1977	4.29
1978	2.12
1979	1.35
1980	——— *
1981	1.10
AVE.	1.89

* Elasticity was not calculated because air demand is not in proportion to GDP.

Then, we retry the forecast for the group A, without using G.D.P. data. Only the transition of achieved volume of transportation is attended. And the Gompertz function as follows is adopted.

$$Y = \alpha EXP\{\beta EXP\{r \cdot t\}\}$$

where
Y = air passenger demand
t = year
α, β, r = parameter

The function accepts the uppermost limit of its value. So, we can set into the function, the uppermost demand calculated from the expected capacities of both Tokyo International Airport (Haneda) and Kansai International Airport (Osaka) which are the feature of group A.

Figure 10 shows the result of above re-forecast. From the figure, forecasted demand in 1990 is 9,140,000, about 6,000,000 smaller than that with model I (15,010,000) or with model II (15,770,000) and about the same with that with model III (10,000,000). Revised forecasts for the overall demand containing above value for group A are 65,410,000 with the combination A, 64,480,000 with the combination B, and 58,750,000 with the combination C (not revised).

As a result of these revision, we finally present our forecast for the overall air demand in 1990 as 59,000,000-65,000,000 (Fig. 11).

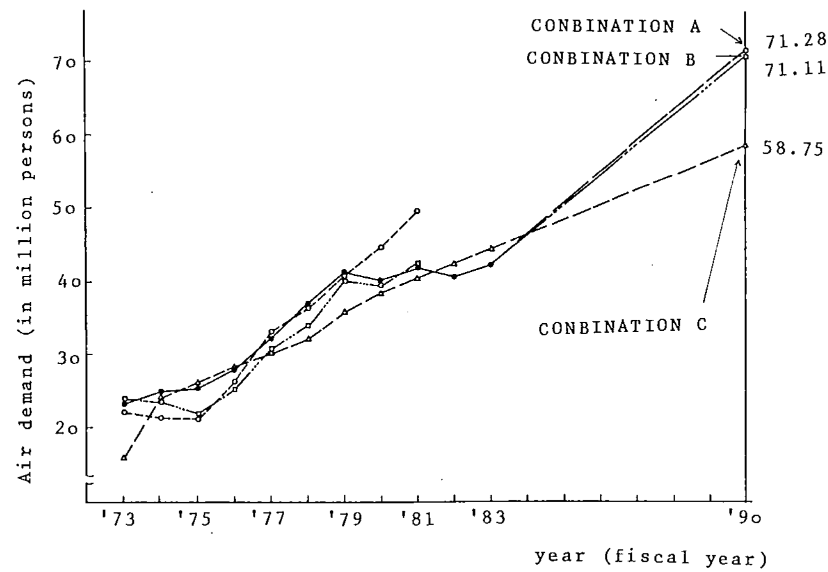

Fig.-9 Forecasted Air Demand in 1990

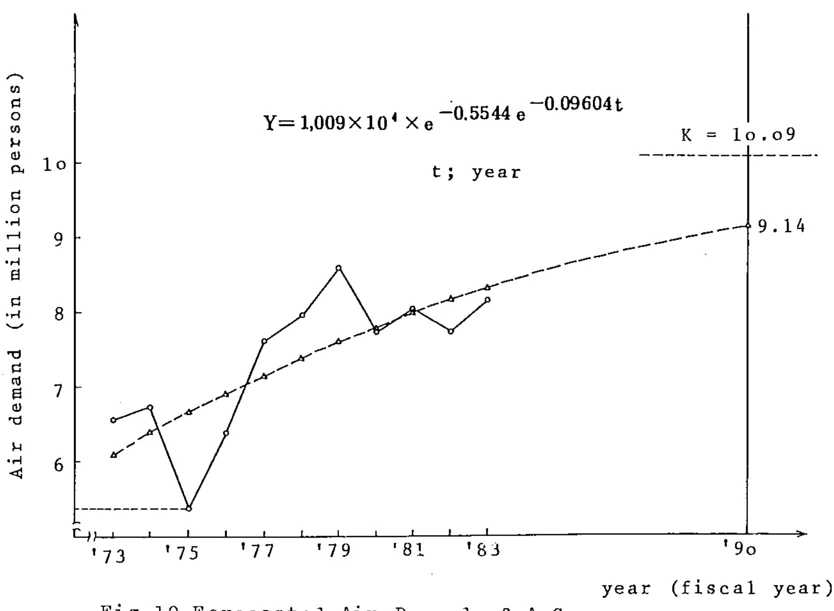

Fig.-10 Forecasted Air Demand of A Group
Using The Gompertz Function

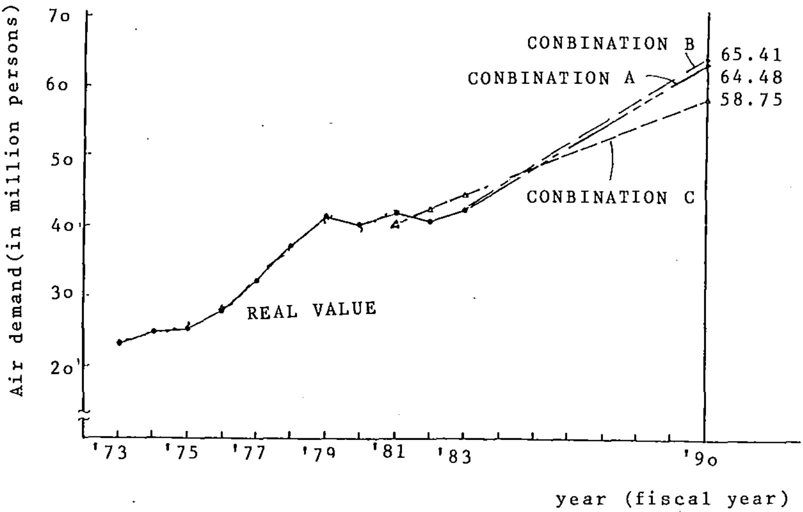

Fig.-11 Forecasting The Air Demand of 1990

6. The feasibility analysis of Commuter air service

(1). Building models for short-range inland routes.

Currently, short-range inland routes are attracting growing attentions. They are important when we discuss about the introduction of air commuter or about the improvement of local area transportation.

But because of the lack of reliable data containing those of car in competition, there exists almost no example of analysis on this category of air transportation.

In this section, we construct mode choice models for the 3 modes of air, rail, car, using newly collected data.

The data analyzed were obtained by questioning the passengers of rail and air between Sapporo and Hakodate (189 km) or Kushiro (291 km). The data about car are by questioning the passengers above about their past movement by car.

Two binary-choice models are built. One is between air and rail and the other is between air and car. The models are in disaggregate Logit form. (Specifications in Tables 12, 13).

From these tables we can say as follows:

(i) "Access and egress time" is an important factor of mode choice on those short-range routes.

(ii) Attributes of passenger and his household or of the trip itself such as "occupation", "income", "number of co-tripper" have some effects on mode choice.

By the above, about short-range inland routes, some techniques of collecting data containing those of cars and analyzing them are presented.

Table-13 Mode Choice Model of Air vs Car

(t-value)

	VARIABLE		MODEL 3	MODEL 4
CAR&AIR	LINEHAUL TIME [MIN.]		-0.01011 (-3.76)	-0.01055 (-4.02)
CAR&AIR	LINEHAUL FARE [YEN]		-0.0004150 (-1.95)	-0.0004600 (-2.19)
CAR&AIR	ACCESS TIME + EGRESS TIME [MIN.]		-0.01271 (-2.11)	-0.01393 (-2.35)
CAR	TRAVEL PERIOD [DAYS]		0.3134 (2.75)	0.3159 (2.78)
CAR	CO-TRAVELERS [PERSONS]		0.9402 (4.97)	0.9776 (5.19)
CAR	BAGGAGE [PIECES/PERSON]		0.7780 (3.40)	0.7969 (3.48)
CAR	CAR LICENSE (DUMMY VARIABLE) (OWNER=1 : OTHERS=0)		0.9026 (2.53)	0.9338 (2.69)
CAR	INCOME (DUMMY VARIABLE) (OVER 6 MILLION [YEN/YEAR] =1 : OTHERS=0)		0.2108 (0.70)	
CAR	CONSTANT *1		-3.8767 (-2.18)	-4.1523 (-2.38)
	NUMBER OF SAMPLES		395	410
	SAMPLE OF EACH MODE (CAR:AIR)		305 : 90	317 : 93
	HIT RATIO	TOTAL [%]	84.6	85.1
	HIT RATIO	EACH MODE [%]	94.8 : 50.0	94.6 : 52.7
	χ 2-VALUE		131.73	139.66
	LIKELIHOOD RATIO		0.2946	0.3045

*1 : MODIFIED BY ESML METHOD

Table-12 Mode Choice Model of Air vs Rail

(t-value)

	VARIABLE		MODEL 1	MODEL 2
AIR&RAIL	ACCESS TIME + EGRESS TIME [MIN.]		-0.02808 (-6.03)	-0.02322 (-4.63)
AIR&RAIL	LINEHAUL TIME [MIN.]		-0.04067 (-3.67)	-0.03910 (3.60)
AIR&RAIL	LINEHAUL FARE [YEN]		-0.0006880 (-2.41)	-0.0006175 (-2.21)
AIR	TRAVEL PURPOSE (DUMMY VARIABLE) (BUSINESS=1 : OTHERS=0)		1.0769 (3.96)	1.1764 (4.31)
AIR	AGE (DUMMY VARIABLE) (30'S,40'S=1 : OTHERS=0)		0.7418 (3.49)	0.6573 (3.03)
AIR	SEX (DUMMY VARIABLE) (MAN=1 : WOMAN=0)		0.7663 (2.12)	1.0598 (2.96)
AIR	OCCUPATION (DUMMY VARIABLE) (COMMERCE,SERVICE,INDUSTRY=1 : OTHERS=0)		1.3537 (5.67)	1.4325 (5.90)
AIR	INCOME (DUMMY VARIABLE) (OVER 5 MILLION [YEN/YEAR] =1 : OTHERS=0)		1.0271 (4.91)	0.9837 (4.75)
AIR	TIME (DUMMY VARIABLE) *1 (UNDER 150 [MIN.] =1 : OTHERS=0)			0.8758 (2.26)
AIR	CONSTANT *2		-8.2793 (-5.10)	-9.1300 (-5.61)
	NUMBER OF SAMPLES		589	589
	SAMPLE OF EACH MODE (AIR:RAIL)		302 : 287	302 : 287
	HIT RATIO	TOTAL [%]	76.1	76.2
	HIT RATIO	EACH MODE [%]	81.1 : 70.7	81.1 : 71.1
	χ 2-VALUE		215.43	218.76
	LIKELIHOOD RATIO		0.2525	0.2554

*1 : TIME = ACCESS + LINEHAUL + EGRESS

*2 : MODIFIED BY ESML METHOD

(2) Feasibility of Air Commuter Service

In this section we forecast the demand for the commuter air service and make analysis on the feasibility of this type of air transportation.

The examples we take are Japanese 19 air routes which are expected to introduce commuter air service (Table 14).

Demand forecast is made by multiplying OD volumes by the share of air transit, and the share was calculated by multiplying the share of rail and car by the rate of transition from these transits to air. In calculating the rate of transition, mode choice models (model1, model 4) were used.

Table 15 shows the volume of air demand against each air fare per kilometer. In the table, we can find only 3 routes have higher unit fares than 80 yen/km (twice of that of YS11) and more annual passengers than 25,000 people/year. Two of these three routes are the routes Gunma-Haneda and the routes Gunma-Narita which are working as the feeders to domestic or over-sea trunk routes. And another is the route Hiroshima-Matsuyama which is between two of principal cities isolated by the water.

The analysis on the feasibility was made by comparing the fares which is the basis of demand forecasting, with the aviation cost calculated on the basis of aviation cost model used by air lines in Japan. To calculate the aviation cost, we sit following 5 financial environments.

Case 1. Standard management
Case 2. No taxed, no gaining
Case 3. Subsidized to operation costs
Case 4. Subsidized to equipment costs
Case 5. No taxed, no gaining and subsidized to both operation and equipment costs.

As a result of the analysis above, only 4 routes were proved to give feasible run in the case 1, and even in the case 4 or 5, only 8 and 12 routes each were proved to be feasible (Table 16).

In summary, many of air routes in Japan are proved to be difficult to run feasible commuter service on them.

Table-14 19 Air Routes Expected to Introduce Commuter Air Service

group	air route	route No.
remoted islans	Sakata-Tobishima	1
	Hagi-Mishima	2
	Naha-Iheya	3
	Naha-Izena	4
between two of principal cities	Komatu-Nagoya	5
	Komatu-Oosaka	6
	Hiroshima-Yonago	7
	Hiroshima-Ooita	8
	Matuyama-Koochi	9
	Hiroshima-Matuyama	1o
	Matuyama-Ooita	11
between principal city and local city	Miyako-Hanamaki	12
	Miyako-Sendai	13
	Kamaishi-Hanamaki	14
	Kamaishi-Sendai	15
	Komatu-Noto	16
	Hiroshima-Masuda	17
feeder to over sea	Gunma-Narita	18
feeder to domestic route	Gunma-Haneda	19

Table-15 The Volume of Air Demand Against Each Air Fare Per Kilometer

route No.	commuter fare per kilometer (yen/ km)			
	5o	6o	7o	8o.
1	29.9	21.6	13.8	7.9
2	25.9	15.3	7.8	3.6
3	2o.6	11.7	3.9	1.o
4	49.4	36.8	19.3	7.2
5	12.4	3.3	o.9	o.3
6	3.5	o.6	o.1	o.o
7	74.8	3o.4	9.8	3.4
8	1o2.6	3o.4	7.3	1.7
9	22.9	21.1	19.5	17.2
1o	634.6	371.4	152.6	53.2
11	8.o	1.3	o.2	o.o
12	7.5	5.8	5.o	4.5
13	o.4	o.1	o.o	o.o
14	23.9	16.8	13.2	11.3
15	3.1	1.6	1.2	1.1
16	9.5	9.2	9.1	9.o
17	42.5	23.7	18.2	1o.8
18	25.o	25.o	25.o	25.o
19	228.o	228.o	228.o	228.o

unit;Thousand persons

Table-16 Feasibility of Air Commuter Service on Each Case

route No.	aviation cost to run feasible(yen/km)				
	case1	case2	case3	case4	case5
1					
2					
3					
4				55	55-65
5					3o
6				3o	3o
7	5o-6o	5o-6o	5o-6o	5o-65	3o-65
8		5o-6o	5o-55	5o-6o	3o-6o
9					7o-8o
1o	6o-8o	55-8o	6o-8o	5o-8o	5o-9o
11					
12					
13					
14					15o
15					
16				12o-15o	1oo-15o
17					5o-55
18	75-15o	7o-15o	75-15o	6o-15o	5o-15o
19	5o-15o	5o-15o	5o-15o	5o-15o	3o-15o

7. Conclusions

In this paper, we made as many kinds of analysis on air demand as the quality of data allows.

Acceptable methods of forecasting whole national demand for air transit were presented, and the methods of forecasting each route's or each commuter route's demand were also presented.

Methods of analysis on the factors of air demand were presented and the analysis on how the factors give their effects on the air demand were made.

The authorized long-term forecast of overall demand was reconsidered. And another forecasted demand (much lower than authorized one) was presented.

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