ANALYSIS OF INTERNATIONAL AIR PASSENGER DEMAND FOR REGIONAL JET SERVICE IN NORTHEAST ASIA

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Abstract: Few international airlines connect small cities in Japan with other Northeast Asian countries because of low passenger demand and the low service frequency of large or mid-sized aircraft. In Europe and America, regional jet (RJ) service has grown dramatically over the past decade. European cities support a more frequent RJ service. This paper examines the feasibility of implementing RJ service to Northeastern Asia. Policy simulations with proposed demand models show that it is possible to implement RJ service for particular load factors and fare patterns. In particular, RJs can replace large and mid-sized aircraft on existing airline routes. We conclude that RJs can offer a better high-frequency service, although passenger demand from small cities in Japan is low.

Key Words: Regional Jet, International Air Passenger, Demand Forecasting

1. INTRODUCTION

Local airports in Japan are gradually starting to service international lines. However, passengers can only make same-day round trips on a few airlines because the frequency of service is low (Figures 1 and 2). The airlines tend to use existing large or mid-sized aircraft because of the low passenger demand for flights from small cities in Japan to neighboring countries. As shown in Figure 2, most local airports (except for Fukuoka) have less than one international flight per day. Hence, travelers who live in small cities have no choice but to use large international airports, such as New Tokyo International Airport (Narita) and Kansai International Airport, which is both time-consuming and expensive.

By contrast, in Europe and America, regional jet (RJ) service has grown dramatically over the past decade (Dresner *et al*., 2002). Generally, RJ airplanes seat fewer than 70 passengers. RJs have operating ranges of up to 3000 km, which almost equals the range of a mid-sized jet, such as an A320-100 (GAO, 2001). The objectives of RJs are to provide point-to-point direct flights between cities and to develop new potential markets for international air passengers. Small cities in Europe have more frequent flights (e.g., 2-3 per day) than do those in Japan as a result of implementing RJ service. Moreover, RJs are 40-60% more fuel-efficient than larger aircraft and 10-60% more fuel-efficient than turboprop aircraft (Babikian *et al*., 2002). Finally and most importantly, RJs are quieter and require a 2-km landing field, which is much shorter than that required for large and mid-sized aircraft.

This paper examines whether sufficient passenger demand exists for the implementation of RJ services in Northeastern Asia. Specifically, it examines whether RJs can offer short-distance international flights from small cities in Japan, which have relatively low passenger demand, to neighboring countries, such as Korea, China, Taiwan, and Hong Kong. To this end, a system for forecasting international air passenger demand has been built and calibrated, and

Figure 1. International flights from local airports in Japan to neighboring countries (November 2002, excluding Narita, Kansai, and Nagoya Airports)

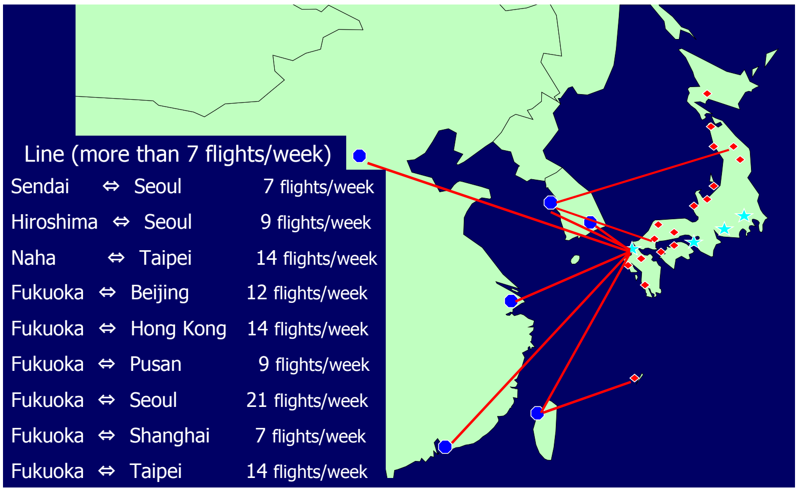

Figure 2. Local airports in Japan with 7 or more international flights per week to neighboring countries (November 2002)

the effects of implementing RJ service between local airports in Japan and cities in other Eastern Asia countries are examined through policy simulations. This paper focuses on the demand side of aviation. We do not consider the supply side (airline strategies); we simply assume that it is feasible for an airline to operate when its load factor exceeds 60%.

2. ANALYSIS OF THE MOVEMENT BETWEEN SMALL CITIES IN JAPAN AND NEIGHBORING COUNTRIES

First, we investigated the potential volume of passenger travel between small cities in Japan and neighboring countries. We used the data from the 1999 biannual survey of international air passengers conducted by the Ministry of Transport of Japan and the data from "Japanese Multinational Facts and Figures" (Toyo Keizai Inc., 1988-1999).

First, the current trends in international air passenger demand from small cities in Japan to neighboring countries were examined using the data from the biannual survey. In many regions of Japan, there are fewer passengers (30-100 passenger per day in each prefecture) than in the large city areas such as Kanto and Kinki Regions. Trips for leisure purposes make up the highest proportion. In choosing airports, most leisure passengers tend to choose the nearest local airport. By contrast, business passengers tend to choose large airports that offer a more frequent service. For the sake of simplicity, only the number of passengers departing from Hokkaido and Tohoku to Korea is shown (Figures 3 and 4).

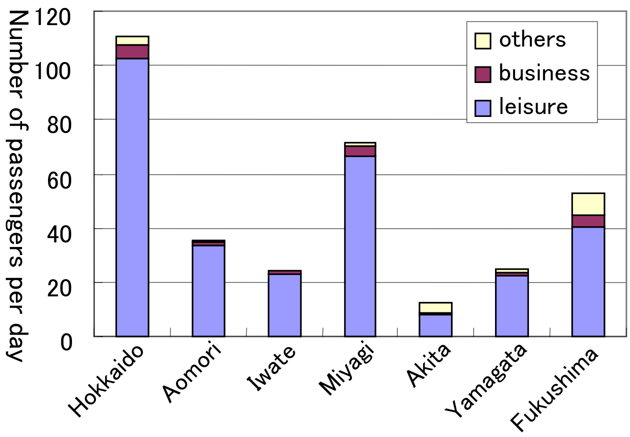

Figure 3. Passengers from the Tohoku Region to Korea (in 1999)

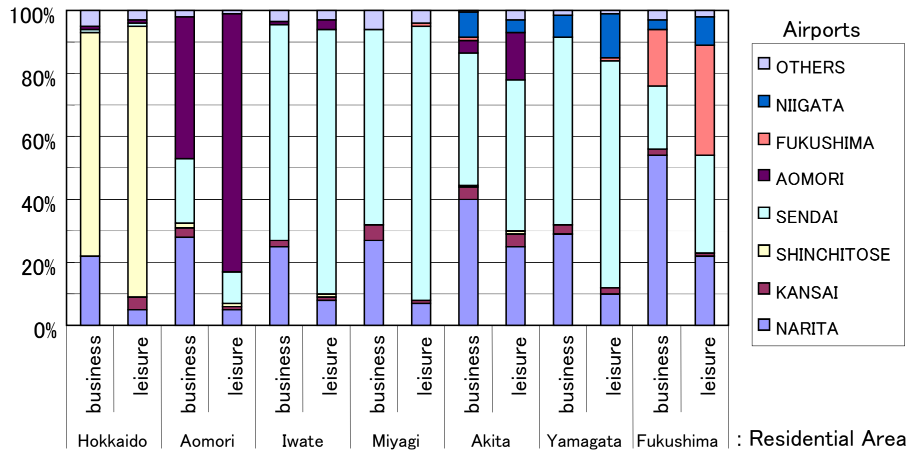

Figure 4. Airport choice behavior of the respondents in the Tohoku Region concerning travel to Korea (in 1999)

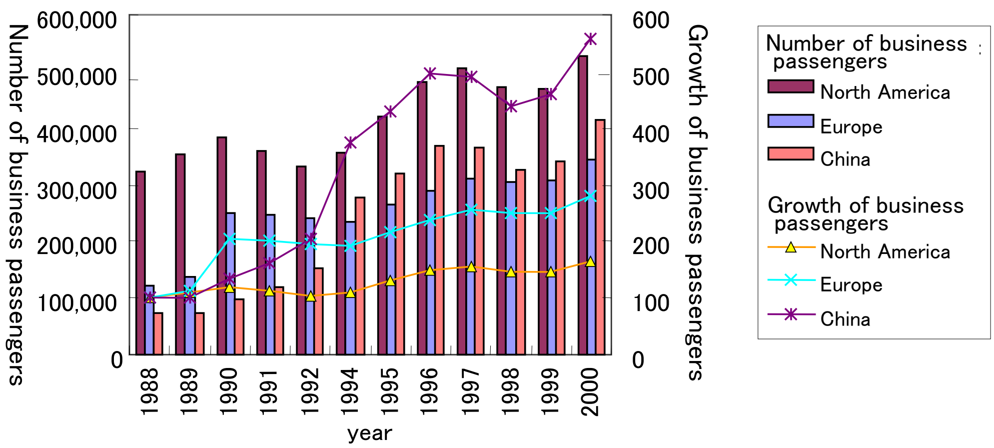

Figure 5. The number of business passengers traveling to China annually

The number of business passengers is very small as compared to the number of leisure passengers. However, business passenger demand to other Asian countries is increasing. The number of passengers to China, in particular, has increased dramatically (Figures 5 and 6). Several factors have caused this growth. We focus on the expansion of Japanese corporations into other Asian countries. Figures 5 and 6 also show that the correlation between the number

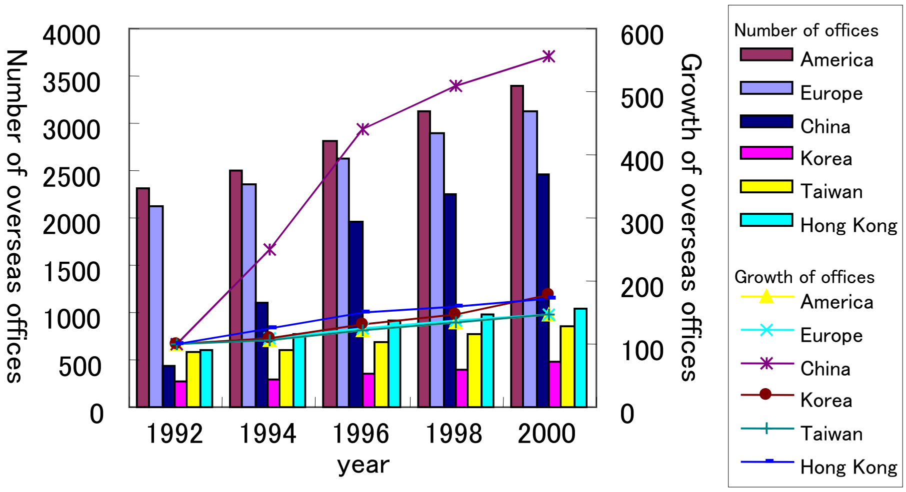

Figure 6. The number of offices of Japanese companies overseas

of business passengers and the number of overseas offices is high. It is thought that the Chinese market will continue to grow. Therefore, we assumed that the number of business passengers from small Japanese cities to other Asian countries, particularly to China, would increase in the near future. Judging from these statistics, the passenger demand from several cities should be concentrated into one regional airport to make RJ service financially feasible.

3. FORECASTING INTERNATIONAL AIR PASSENGER DEMAND

3.1 Outline of the Demand Model and Data

In order to analyze whether the implementation of RJ service in Japan is feasible, we forecast international air passenger demand from small Japanese cities to neighboring countries using a demand model. The method of forecasting international passenger demand used in this study is based on the model proposed by ITPS (2001). As compared with the ITPS model, we incorporated several minor changes into our proposed model in order to investigate regional jet service in Northeast Asia. For example, as with airport and access-mode choice models, we only used samples of local residents to calibrate the model. In addition, for business passengers, we defined three alternative airports (primary airport: PA, secondary airport: SA, and local airport: LA) and for leisure passengers, we defined two alternative airports (primary airport: PA, and local airport: LA). The reason for this is that the roles of airports differ, according to where the passengers live. Our model reflects this phenomenon.

The demand forecasting system consists of models for trip production, trip generation and attraction, trip distribution, airport choice, and airport access-mode choice. Figure 7 shows the forecasting process. The accessibility index, calculated in the airport access choice model, is used in the airport choice, trip distribution, and trip generation models. Of course, we need to consider the slot limitation of each airport. However, this paper assumes that airlines have sufficient slot capacity between Japanese local cities and neighboring countries. International hub airports in neighboring countries, such as Shanghai International Airport and Incheon International Airport, have the capacity to create new runways in response to growing demand. Hence, we abstract the effects of slot capacity in this paper.

Our model focuses only on passengers departing from Japan to other Northeast Asian countries. We do not consider North and South America, Europe, other Asian countries, and so on. The basic data for calibrating the proposed model are shown in Table 1.

3.2 Geographic Area and Zones Considered

The operating range of RJs is about 1,600 miles (2,560 km); this may be compared with the practical range of turboprop aircraft of 350 miles (GAO, 2001). Specifically, the service range of the CRJ-200ER is over 3000 km and it can cover a wide area of Eastern Asia, starting from Tokyo (Figure 8).

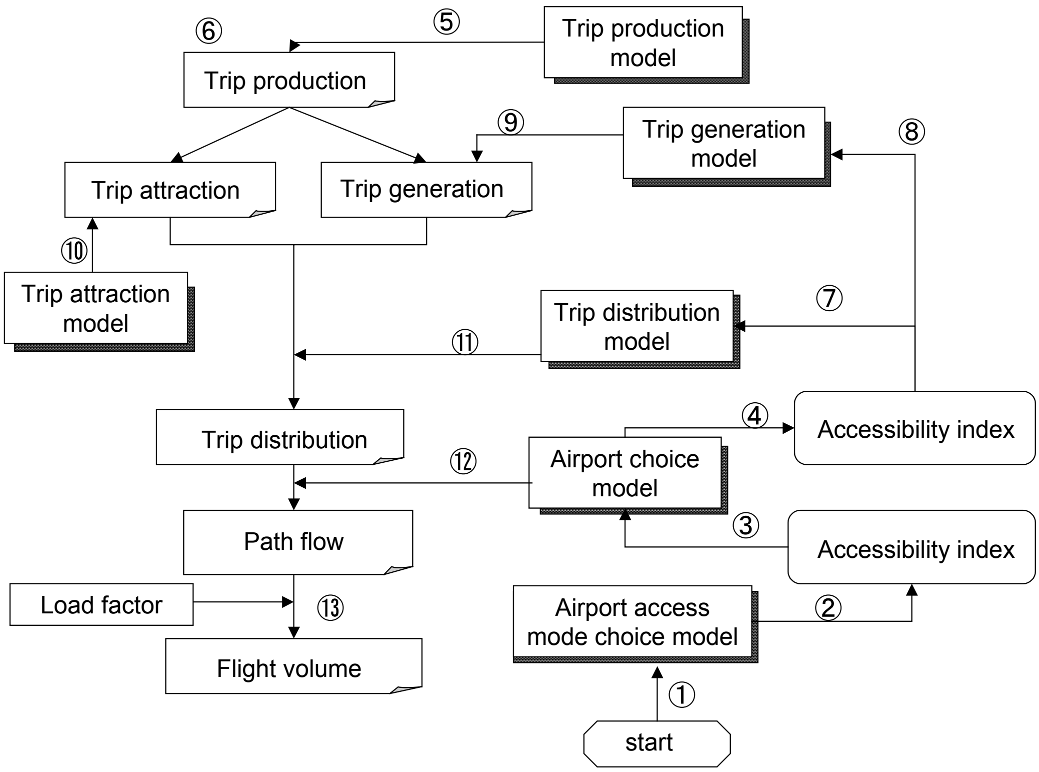

Figure 7. Algorithm used to forecast international air passenger demand

Table 1. Summary of the data used to calibrate the demand models

(a) Trip

Data	Resources [Organization] (Year)
• Individual choice data for airport and access-mode • Origin-Destination trips (scaled-up) • Total number of trips generated and originating from each zone in the study area (scaled-up)	• Biannual Survey on International Air Passengers [Ministry of Transport, Japan] (1999)
• Total number of trips generated from all of Japan	• Annual Report of Statistics on Legal [Ministry of Justice, Japan] (1985-1992, 1994-1999)

(b) Level of Service

Data	Resources [Organization] (Year)
• Access time and cost for each airport	• Eki-Spart - Software for finding the shortest path of transportation networks in Japan [Val Laboratory Corporation, Japan] (1999) • NAVINET System (http://www.mlit.go.jp/seisakutokatsu/ soukou/navinet/navinethp.html) [Ministry of Land, Infrastructure and Transport]
• Frequency of airline service for each airport	• JTB Timetable [Japan Travel Bureau] (1999)
• Fare for airline service	• Self-Administered Telephone Survey to Travel Agencies (2002)

(c) Socio-Economic Indicators

Data	Resources [Organization] (Year)
• GDP and GRP of Japan	• Annual Report on National Accounts [Economic Planning Agency, Government of Japan] (1985-1999)
• GDP and GRP of other countries	• Principal Economic Indicators of Overseas [Bank of Japan] (1985-1999)
• Affiliates and branches of Japanese companies in Northeast Asian countries	• Japanese Multinationals Facts and Figures [Toyo Keizai INC., Japan](1985-1999)

Figure 8. Target area of the demand-forecasting model

Table 2. The destination zones

Destination Zone	Principal Cities, Regions, or Countries
1. Beijing	Beijing, Tianjin
2. Shanghai	Shanghai, Nanching, Suzhou, Hangzhou
3. North China	Dalian, Qingdao, Shenyang, Haerbin, Changchun
4. Guangzhou	Guangzhou, Hongkong, Shenzhen, Xiamen, Haikou
5. West China	Chengdu, Chongqing, Xian, Kunming
6. Korea	Korea
7. Taiwan	Taiwan
8. Southeast Asia	Thailand, Vietnam, Cambodia, Myanmar
9. Singapore	Singapore
10. Indonesia	Indonesia
11. Philippines	Philippines
12. Malaysia	Malaysia

We defined seven destination zones based on the service range of RJs. These are summarized in Table 2. We defined five additional destinations, based on improvement in the service range of RJs (No. 8 to 12 in Table 2). By contrast, we considered 207 origin zones in Japan consisting of regions for each airport and the access-mode choice model, and 47 prefecture zones for the trip generation, attraction, and distribution models. The zones for the 207 regions are based on the definition in the "Biannual Survey of International Air Passengers".

3.3 Airport and Access-Mode Choice Model

(1) Model Formulation

We applied disaggregate nested-logit models to the combined access-mode-airport-choice behavior of passengers. A two-level nested-logit model with airport choice at the upper level and access mode choice at the lower level is preferred (*e.g.*, Pels *et al*, 2002).

Suppose that a traveler has to fly to a particular destination (airport) and he/she has to decide the airport and access mode simultaneously. The passenger chooses the alternative that maximizes the total utility of the airport (r) and access mode (m) combination.

Let there be a set C_{rij} of airports for O-D-pair i and j, and a set C_{ac_ir} of access modes from origin zone i to airport r. The probability that a passenger leaving zone i for zone j with purpose p (= business or leisure) chooses airport r as the first option is formulated as:

$$P_{ijr}^{p} = \frac{\exp\left[\alpha_{\text{freq}}^{p} \ln\left(\text{freq}_{rij}\right) + \alpha_{\text{fare}}^{p} \text{fare}_{rij} + \tilde{V}_{rij}^{p}\right]}{\sum_{r \in C_{ij}} \exp\left[\alpha_{\text{freq}}^{p} \ln\left(\text{freq}_{rij}\right) + \alpha_{\text{fare}}^{p} \text{fare}_{rij} + \tilde{V}_{rij}^{p}\right]} \quad (1)$$

$$\tilde{V}_{rij}^{p} = \mu_{r}^{p} \ln\left[\sum_{m \in C_{ac\_ir}} \exp\left(\frac{\beta_{m}^{p} + \beta_{\text{cost}}^{p} \text{cost}_{m} + \beta_{\text{time}}^{p} \text{time}_{m} + \beta_{d_1}^{p} d_1 + \beta_{d_2}^{p} d_2}{\mu_{r}^{p}}\right)\right] \quad (2)$$

Where, freq_{rij} is the weekly frequency of service from zone i to zone j in logarithmic form and indicates the size of the airline in the market to a particular destination. The average fare from airport r to destination zone j (fare_{rij}) is included. Furthermore, the "accessibility index" to airport r ($\tilde{V}_{rij}^{p}$), which represents the maximum expected utility of alternative access modes, is also included. The passenger chooses an access mode based on the access cost (cost_m) and time (time_m). We use two dummy variables: d_1 and d_2, such that $d_1 = 1$ if the respondent accesses any airport by car and the total access time is less than one hour, otherwise $d_1 = 0$ and $d_2 = 1$ if the respondent accesses the local airport (defined in the next section) by car. Finally, α_{freq}^{p}, α_{fare}^{p}, μ_{r}^{p}, β_{m}^{p}, β_{cost}^{p}, β_{time}^{p}, $\beta_{d_1}^{p}$ and $\beta_{d_2}^{p}$ are unknown parameters.

(2) Estimation Results

The source of the basic data used for the estimates in the model is the "1999 Biannual Survey of International Air Passengers", which was conducted by the Ministry of Transport of Japan. The airport and access-mode choice model only used those respondents who left a local region in Japan for Northeast Asian countries, based on their stated destination.

We defined the available airports and access-modes for each passenger, as shown in Figure 9. For business passengers, three alternative airports (primary airport: PA, secondary airport: SA, and local airport: LA) and two alternative access modes (public transport and private car) are considered. For leisure passengers, two alternative airports (primary airport: PA, and local airport: LA) and two alternative access modes (public transport and private car) are considered. These terms are defined in Table 3.

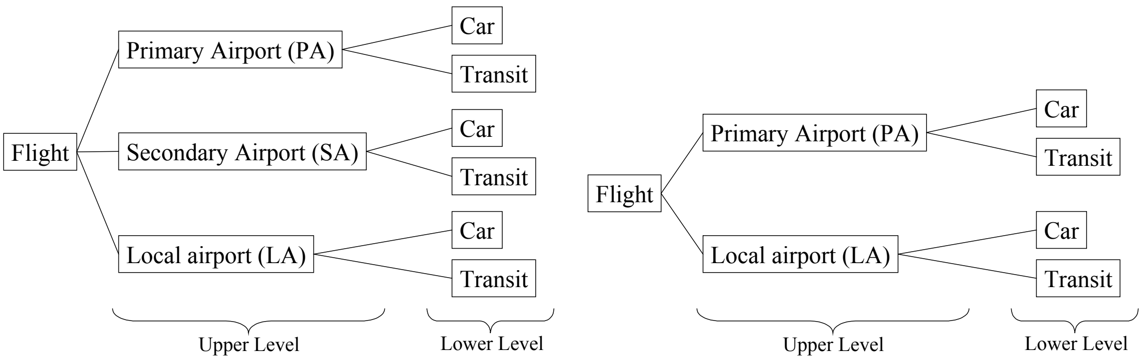

Figure 9. Nested choice structures of airport and access-mode

Table 3. Definitions of alternative airports

(a) Business

Primary Airport (PA)	・ NARITA for residents living in eastern Japan ・ KANSAI for residents living in western Japan
Secondary Airport (SA)	The airport with the greatest frequency of flights other than PA and LA
Local Airport (LA)	The local airport with the shortest access time from the residential area

(b) Leisure

Primary Airport (PA)	The airport with the greatest frequency of flights other than LA
Local Airport (LA)	The local airport with the shortest access time from the residential area

Table 4. Estimates using nested logit model for choice of airport and access mode

	Business		Leisure	
	Coeff.	t-ratio	Coeff.	t-ratio
Lower Level (Access Mode Choice)				
time (min)	-0.0150	-3.38	-0.0111	-4.80
cost (yen)	-1.70×10^{-4}	-3.04	-2.28×10^{-4}	-3.10
Car-Specific Constant	-1.60	-4.90	-0.636	-5.16
$d1$	1.45	4.03	0.806	5.49
$d2$	1.40	4.40	1.26	6.98
Upper Level (Airport Choice)				
ln[freq]	0.556	3.08	0.182	0.902
fare (yen)	-	-	-1.44×10^{-4}	-1.23
Accesibility Index	0.889	4.01	0.780	4.40
Adjusted Log-Likelihood Ratio	0.471		0.450	
Observations	221		934	
Value of time (yen/min)	88.4		48.7	

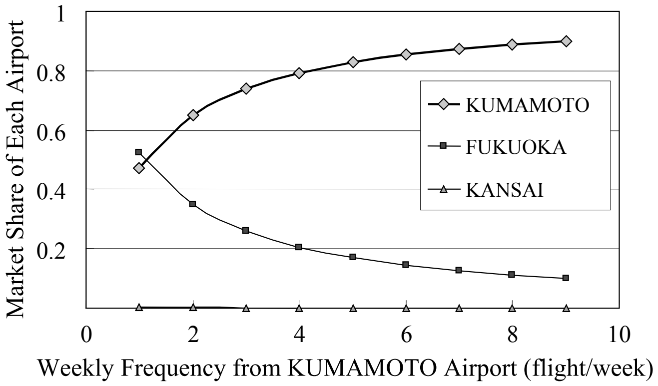

Figure 10. Sensitivity analysis of the airport choice model with respect to the frequency of flights from Kumamoto Airport (Kyushu Island, Business Trips)

The estimates are presented in Table 4. Most of the estimates come out with the expected sign and are significantly different from zero at the 5% significance level, except for the frequency and the fare of leisure purpose. We discard the variable $fare_{rij}$ for business trips since the estimates are positive and statistically insignificant.

From the estimates, we can calculate the value of time (VOT). The VOT is 88.4 (yen/min) for business passengers and 48.7 (yen/min) for leisure passengers. ITPS (2001) reports that the VOT is 58.6 (yen/min) for business and 53.5 (yen/min) for leisure purposes using the same data. The VOT for business purposes is higher than in the ITPS case, mainly because we only used subjects living in small cities in Japan for the estimates and no subjects living in large cities with high VOTs. In terms of the statistical goodness of fit, these results were suitable for our research, so we adopted them.

The result of the sensitivity analysis for the choice model is shown in Figure 10. If the frequency of airline service increases, the market share of the airport will grow logarithmically. By instituting RJ service into local airports in Japan, the daily frequency of airline services to neighboring countries will increase. Hence, our model can simulate the effect of implementing RJ service.

3.4 Trip Distribution Model

(1) Model Formulation

The gravity model is applied to the aggregate trip distribution model for business purposes.

For leisure trips, we assumed that the future trip distribution pattern is the same as the present pattern. Therefore, we only formulate a trip distribution model for business purposes below.

The form of the gravity-type trip-distribution model for business travelers is:

$$T_{ij}^{b} = \exp\left(\gamma_{c}^{b}\right) \cdot \left(A_{j}^{b}\right)^{\gamma_{A}^{b}} \cdot \left(G_{i}^{b}\right)^{\gamma_{G}^{b}} \cdot \exp\left(\gamma_{\text{logsum}}^{b} \text{logsum}_{ij}^{b}\right) \tag{3}$$

Where, the superscript "b" denotes business purposes, T^{b}_{ij} is the passenger trip (passengers/year), A^{b}_{j} is the total trip attractions (passengers/year) for business trips for zone j, G^{b}_{i} is the total trips generated (passengers/year) for business trips to zone i, and logsum^{b}_{ij} is the "accessibility index" for business calculated from the airport and access-mode choice model. Finally, γ^{b}_{A}, γ^{b}_{G}, γ^{b}_{c} and $\gamma^{b}_{\text{logsum}}$ are unknown parameters. The index is defined as:

$$\text{logsum}_{ij}^{b} \equiv \ln\left\{\sum_{r \in C_{ij}} \exp\left[\hat{\alpha}_{\text{freq}}^{b} \ln\left(\text{freq}_{rij}\right) + \tilde{V}_{rij}^{b}\right]\right\} \tag{4}$$

For leisure purposes, the accessibility index is defined as follows:

$$\text{logsum}_{ij}^{l} \equiv \ln\left\{\sum_{r \in C_{ij}} \exp\left[\hat{\alpha}_{\text{freq}}^{l} \ln\left(\text{freq}_{rij}\right) + \hat{\alpha}_{\text{fare}}^{l} \text{fare}_{rij} + \tilde{V}_{rij}^{l}\right]\right\} \tag{5}$$

Note that this value is not used to calculate a trip distribution for leisure purposes since we assume that the extant leisure trip distribution pattern will not change in the future.

Due to the existence of accessibility indexes, the proposed integrated model system assumes that the change in service level of each airport (*e.g.*, the increase in the daily frequency) can affect the upper level trip pattern in the demand-forecasting procedure. For example, the trip distribution pattern for international business passengers will change with improvement in the service level for a particular airport. By contrast, we assume that the future trip distribution pattern for leisure purposes will remain as is.

(2) Estimation Results

The O-D flow data were derived from the 1999 biannual survey of international air passengers. Since this is a sample of international passengers, the trip data are scaled up to the annual O-D flow for each O-D pair.

The estimates for the trip distribution model for business purposes are shown in Table 5. To estimate the parameters, we used 516 of the 564 combinations of origin and destination zones. There were no observed data for the remaining O-D pairs. All the estimates come out with the expected sign and are significantly different. In addition, the coefficient of determination (R^2) is relatively high.

Table 5. Estimation Results of the Trip Distribution Model with Business Purpose

Parameters	Estimates	t-ratio
γ^{b}_{G}	0.985	23.3
γ^{b}_{A}	0.919	16.8
$\gamma^{b}_{\text{logsum}}$	0.0665	2.42
γ^{b}_{c}	-13.2	15.9
F-statistic	402	
R^2	0.702	
Observations	516	

3.5 Trip Generation Model

(1) Model Formulation

The model that generated trips from Japan to Northeast Asian countries was based on the "basic unit method". We assumed that the number of international travel passengers originating in zone i is a function of socio-economic indicators and accessibility. The trip generation model for trip purpose p is specified as follows:

$$G_i^p = \exp\left(\eta_c^p\right)\cdot\left(GRP_i\right)^{\eta_{GRP}^p}\cdot\exp\left(\eta_{\text{logsum}}^p \text{logsum}_i^p\right) \qquad (6)$$

Where, GRP_i is the gross regional product for secondary and tertiary industries in origin zone i, logsum_{ij} is the "accessibility index" calculated from the trip distribution model, and $\eta^p{}_{GRP}$, $\eta^p{}_c$ and $\eta^p{}_{\text{logsum}}$ are unknown parameters. The variable $\text{logsum}^p{}_i$ for trip purpose p is also defined as the weighted mean of $\text{logsum}^p{}_{ij}$ using the flow of trips $T^p{}_{ij}$.

$$\text{logsum}_i^p \equiv \frac{\sum_j T_{ij}^p \cdot \text{logsum}_i^p}{\sum_j T_{ij}^p} \qquad (7)$$

As with the trip distribution model, the trip generation model incorporates feedback from other models (trip distribution and airport and access-mode choice models).

(2) Estimation Results

The estimates of the trip generation model for both business and leisure purposes are shown in Table 6. Forty-seven observations, corresponding to the number of origin zones in Japan, were used for the estimates.

3.6 Trip Attraction Model

(1) Model Formulation

The trip attraction model for each destination in Northeast Asian countries is a linear function of the socio-economic indexes of each destination. This paper focuses on the index that represents the degree of business involving Japanese companies. The regression

Table 6. Estimation results using the trip generation model

(a) Business

Parameters	Estimates	t-ratio
$\eta^b{}_{GRP}$	1.08	16.7
$\eta^b{}_{\text{logsum}}$	0.237	5.96
$\eta^b{}_c$	-7.19	7.05
F-statistic	257	
R^2	0.921	
Observations	47	

(b) Leisure

Parameters	Estimates	t-ratio
$\eta^l{}_{GRP}$	0.971	27.9
$\eta^l{}_{\text{logsum}}$	0.239	9.09
$\eta^l{}_c$	-3.19	5.49
F-statistic	542	
R^2	0.961	
Observations	47	

Table 7. Estimates of the trip attraction model for business purposes

Parameters	Estimates	t-ratio
$\theta^b{}_Y$	74.6	3.14
$\theta^b{}_{GRP}$	535	5.23
$\theta^b{}_c$	-4.22×10^4	1.66
F-statistic	21.9	
R^2	0.829	
Observations	12	

model for business trips is formulated as:

$$A_j^b = \theta_{GRP}^b GRP_j + \theta_Y^b Y_j + \theta_c^b \tag{8}$$

Where, Y_j is the total number of affiliates in destination zone j, and $\theta^b{}_{GRP}$, $\theta^b{}_Y$, and $\theta^b{}_c$ are unknown parameters.

We assume that the ratio of leisure trips to each destination will not change in the future. That is, the share of leisure trips for each destination is constant forever. Hence, the current trip share and future total trips determine the future attracted trips.

(2) Estimation Results

The estimates of the trip attraction model for business purposes are shown in Table 7. Twelve observations, corresponding to the number of overseas destination zones (see Table 2), are used for the estimation. Although the sample is relatively small, the estimates are statistically significant and the goodness of fit is high.

3.7 Trip Production Model

(1) Model Formulation

For business purposes:

$$Z^b = \lambda_{GDP}^b GDP + \lambda_Y^b Y + \lambda_c^b \tag{9}$$

For leisure purposes:

$$Z^l = \lambda_{GDP}^l GDP + \lambda_{RATE}^l RATE + \lambda_c^l \tag{10}$$

Where, Z^b and Z^l are the total overseas trips from all of Japan, in a year, for business and leisure purposes, respectively, GDP is the annual gross domestic product of Japan, Y is the total number of affiliates in Northeast Asian countries, and $\lambda^b{}_{GDP}$, $\lambda^b{}_Y$, $\lambda^b{}_c$, $\lambda^l{}_{GDP}$, $\lambda^l{}_{RATE}$, and $\lambda^l{}_c$ are unknown parameters. The difference in producing business and leisure trips is that the former considers the effects of the strength of Japanese companies and the latter considers the effects of the currency exchange rate.

(2) Estimation Results

The estimates of the trip production model for both business and leisure purposes are shown in Table 8. We applied the data from the "Annual Report of Legal Statistics" (1985-1992 and 1994-1999) as the dependent variable. Unfortunately, the data for 1993 are missing, so there are 14 observations. Although the sample is relatively small, the estimates are statistically significant and the goodness of fit for each trip purpose is high.

Table 8. Estimates of the trip production model

(a) Business

Parameters	Estimates	t-ratio
$\lambda^b{}_{GDP}$ (1 bilion yen)	1.33	1.75
$\lambda^b{}_Y$	121	6.45
$\lambda^b{}_c$	-4.18×10^5	1.70
F-statistic	205	
R^2	0.974	
Observations	14	

(b) Leisure

Parameters	Estimates	t-ratio
$\lambda^l{}_{GDP}$ (1 bilion yen)	15.5	8.59
$\lambda^l{}_{RATE}$	-5.12×10^3	1.42
$\lambda^l{}_c$	-2.11×10^6	1.72
F-statistic	117	
R^2	0.955	
Observations	14	

4. POLICY ANALYSIS CONCERNING THE IMPLEMENTATION OF REGIONAL JET SERVICE

Finally, we examine whether the implementation of RJ service in Japan is feasible, using the demand model proposed in the previous chapter and assuming a future socio-economic scenario for Japan and other Northeast Asian countries. By implementing RJs, airlines departing from local airports in Japan to neighbor Northeast Asian countries can offer better services with higher frequency than at present. Here, we assume that RJs are implemented in 2010 in the three scenarios described below.

4.1 Setting the Future Socio-Economic Scenario

It is generally said that Japan will have low economic growth. However, the number of affiliates of Japanese companies in East Asia will increase because of the rapid globalization of large companies, the overseas transfer of production sites, and so on. Hence, we assume that the current average growth rate will continue.

For the future economic situation in other Asian countries, we expect that a high economic growth rate will persist. In particular, China will experience even more economic growth because of the 2008 Olympic games (Beijing), the 2010 International Exhibition (Shanghai), and so on. With this social and economic background, we assume the future socio-economic scenario for Japan and other countries shown in Table 9.

4.2 Simulation Case 1: Substituting RJ Service for existing Mid-sized Jet Service

First, we simulate the case in which RJ aircraft replace current airline services using mid-

Table 9. Future scenario based on socio-economic status (to the year 2010)

The annual growth rate of GDP in Japan		0.6〜1.9 (%) [Predicted by Cabinet Office of Japan]
The annual growth rate of GRP for secondary and tertiary products in local regions in Japan		0.6〜1.9 (%) [The same with GDP in Japan]
The total number of affiliates Japanese companies in East Asia		Assume that the current average growth rate (up to 2001) will continue in the future
Exchange rate		120 (yen/$) [fixed]
The annual growth rate of GDP (Foreign countries)	China	7.5 (%) [fixed]
	Other Asian Countries	4 (%) [fixed]

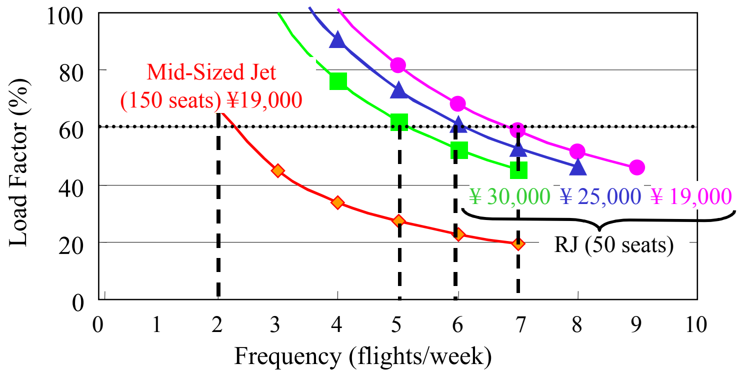

Figure 11. Relationship between trip frequency and load factor for airlines (Nagasaki-Shanghai Route, in 2010)

sized aircraft. In concrete terms, we examine the case in which a RJ such as the ERJ 145 (50 seats) takes over the current Nagasaki-Shanghai route (mid-sized jet, 150 seats, 2 flights/week). The current single fare between these cities is 19,000 yen (in November 2002).

Figure 11 shows the relationship between airline service frequency and load factor. Predicting the air passenger demand in 2010 with our proposed model, we can derive this relationship. Generally, the smallest financially feasible load factor is about 60%. Using this criterion, the maximum frequency of flights with a mid-sized jet to maintain airline profitability is two flights per week. By contrast, if RJs take over this route, the air carrier can offer more frequent service than it can with a mid-sized jet. If we assume that the RJ fare equals the current single fare (19,000 yen), the air carrier can offer a one-day shuttle service (7 flights/week). Figure 11 implies that RJs can be operated at high frequency, even if the fare increases.

4.3 Simulation Case 2: Concentrating Passenger Demand from Surrounding Regions on a Particular Airport with RJ Service

Second, we simulate the case in which airline service starts on a new route using RJs. There is no regular flight between the Tohoku Region in Japan and Taipei at present (November 2002). We assume that Sendai airport in Miyagi Prefecture will start RJ service to Taipei, and that the passenger demand from other regions in Tohoku will be concentrated on Sendai airport. A snapshot of the policy scenario is shown in Figure 12.

Table 10 compares the predicted air passenger demand and the market share for Sendai airport, and the predicted least frequency to make the airline financially feasible in 2010. The

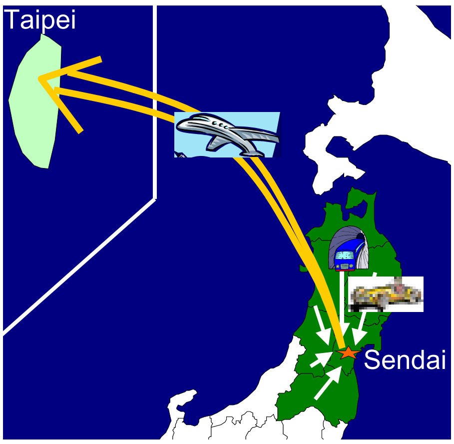

Figure 12. Basic concept for implementing RJ into Sendai Airport

Table 10. Passenger demand after implementing RJs between Taipei and Sendai (in 2010)

One-way Fare	The number of passengers departing from Sendai Airport (person/year)			Market Share of Sendai Airport bound for Taipei from Tohoku Region			The lowest frequency giving a load factor of more than 60% (flights/week)		
	Mid-Sized Jet		RJ	Mid-Sized Jet		RJ	Mid-Sized Jet		RJ
25,000 yen	25,833	<	27,320	0.79	<	0.84	5	<	17
30,000 yen	23,711	<	25,282	0.73	<	0.78	5	<	16
35,000 yen	20,709	<	22,595	0.64	<	0.69	4	<	14

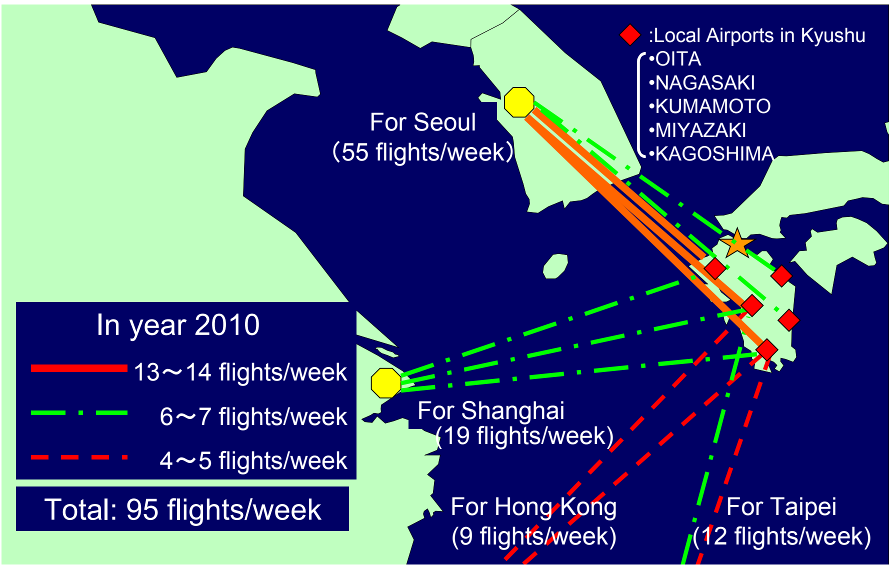

Figure 13. Financially feasible routes using RJs from airports on Kyushu Island to Northeast Asian cities in 2010 (the load factors exceed 60%)

cases with a mid-sized jet (150 seats) and a RJ (50 seats) are compared. Since the service frequency from Sendai airport is improved with the implementation of RJs, the number of passengers from Sendai and its market share increase. Judging from the predicted service frequency level, it follows that an air carrier can offer more than 2 flights/day if the passenger demand from the entire Tohoku region is concentrated into Sendai airport.

4.4 Simulation Case 3: Decentralized Implementation of RJs into Multiple Local Airports

Third, we consider the case in which the implementation of RJs is dispersed to a number of local airports throughout Japan. We examined and discussed the case of Kyushu Island. We assume that airline service between local airports in Kyushu (*e.g.*, Oita, Nagasaki, Kumamoto, Miyazaki, and Kagoshima) and Northeast Asian cities will replace existing routes or create new routes with the decentralized implementation of RJs.

A rough sketch of financially feasible airline routes in 2010, whose load factors exceed 60%, is shown in Figure 13. At present (November 2002), no airline services offer more than 7 flights/week from Kyushu Island, except for Fukuoka airport. By implementing RJs, however, several new airline routes are feasible. For example, the maximum service frequency of a new Nagasaki-Seoul route using RJs is calculated to be 14 flights/week.

5. CONCLUSIONS

This paper proposes a model for forecasting international-air-passenger demand in order to examine whether implementing RJ service from small cities in Japan to neighboring countries is feasible. Policy simulations show that it is possible to implement RJ service to Northeastern Asia, given specific load factors and fare patterns. Specifically, RJs can replace large and mid-sized aircraft operating on short international routes, such as Nagasaki-Shanghai and Kumamoto-Seoul. Finally, it is implied that RJs can offer better service with high frequency, even if the passenger demand from small cities in Japan is low.

In future research, it would be useful to improve the demand model by incorporating other socio-economic indicators. The structure of the proposed model is very simple and travelers from Northeast Asian countries to Japan are not considered. Furthermore, it is important to examine the use of RJs from the perspective of the air carriers. Little is known about the cost and expenses of RJs. Scheduling of RJ aircraft should also be considered. From the results of these analyses, it is expected that an optimal-pricing and aircraft-allocation policy for RJ service in Northeastern Asia can be proposed.

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