Journal of the Eastern Asia Society for Transportation Studies, Vol.8, 2010

Comparative Analysis of Domestic Passenger Flight Frequency between Japan and US Aviation Market

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Abstract: Due to the capacity constraint of Haneda Airport, airlines in Japan have to rely on large-size aircrafts to increase capacity for transporting increasing volume passenger in domestic aviation. Consequently the average aircraft-size has been unusually large in Japanese domestic market in comparison with the other western countries. This means that level of service in terms of the flight frequency is low in many air routes in Japan. In this study, first, we broadly compare the flight frequency and aircraft size among major countries. Second, in order to get an idea on the potential flight frequency, we analyze the flight frequency in US and Japan from taking into account the characteristics of each air route such as passenger demand, route distance and number of airline entries. The study results, though based on simple quantitative analysis, provide valuable insights for policy makers concerning future strategies in expanding capacity of Haneda Airport.

Key Words: *passenger flight frequency, aircraft size, airport capacity constraint*

1. INTROUCTION

In Japan, domestic air passengers have concentrated to Haneda airport, which is a major airport for domestic services in Tokyo metropolitan area (over 60% of all domestic passengers in Japan is the passengers to/from Haneda airport), and the runway capacity of Haneda has been always insufficient. In recent years, some of the local airports like Fukuoka and Naha also have a difficulty to accommodate the needs to increase frequency or open new route due to the runway capacity constraint. By 2010, Haneda airport, the most congested airport in Japan, is scheduled to expand and have 1.4 times the current runway capacity with its new fourth runway (some portion of slots (take-off/landing right in a specific time) will be allocated to international flights whereas current slots are basically allocated only to domestic flights). However, the expanded capacity is expected to be fully used again in few years time depending on the market changes such as higher frequency operation and denser network with more small-sized aircrafts including Regional Jet. So far, airlines in Japan have increased the capability for conveying air passengers by enlarging aircraft size due to the lack of runway capacity especially in Haneda, and consequently the average aircraft-size in Japanese domestic air market is much bigger in comparison with the other western countries. This means that level of service in terms of the flight frequency is low in many air routes in Japan. In terms of passengers' benefit, higher frequency is better whereas most passengers do not usually care the size of the aircraft they use. Therefore, airlines in Japan are expected to increase the flight frequency to attract more passengers in competition among different airlines after the capacity expansion at Haneda. And the increase of frequency can be usually achieved by down-sizing aircraft unless there is the passenger volume requires otherwise.

The objectives of this study are, first, to broadly compare the flight frequency and aircraft size

(number of seats) among major countries in the world; and second, to see the potential flight frequency by analyzing the flight frequency in US and Japan from the view point of the characteristics of each air route such as passenger demand, route distance and number of operating airlines.

In fact, previous researches also focused on the flight frequency and aircraft size. By modeling the behaviors of airlines and/or passenger, many researches tried to estimate the flight frequency and/or aircraft-size (and/or air fare etc), for example Hsu, et al (2003), Wei, et al (2005, 2007), Takebayashi (2008)). Takebayashi (2008) developed demand-supply interaction model with consideration of runway capacity constraint, and simulated the frequency and aircraft size change after the capacity expansion for the hypothetical network. These kinds of model analysis are very important for understanding airlines' and passengers' behavior and for analyzing the impacts of some policies within a scientific framework. This study takes a different approach, that is, more simple statistical analysis of the relationship between actually realized flight frequencies and route characteristics at each route. Hansen et al (2001) analyzed the aircraft size at different routes from 18 US major airports by considering the route characteristics such as passenger demand, route distance, concentration (level of monopoly) and capacity constraints etc. This study uses the same database as Hansen et al (2001) with recent updates, and T-100 Domestic Segment Database (Bureau of Transportation Statistics, US). And we take a same approach for a comparative analysis of flight frequency between in Japan and in US, and see its difference as one reference of a potential frequency in Haneda route in Japan without runway capacity constraints.

2. AN OVERVIEW OF FLIGHT FREGUENCY AND AIRCRAFT SIZE AMONG MAJOR AIRPORTS IN SELECTED METROPOLITAN AREA WORLDWIDE

In US and Europe, airlines have attempted to enhance the level of service by increasing flight frequency to attract more passengers, especially business passengers. The competition with Low Cost Carrier (LCC), emergence of new cost-efficient Regional Jet (RJ) and the recent change in passenger preference for point-to-point service, have also promoted these high frequecy services. Figure 1 shows the average seat capacity per flight and annual passenger volume of major airports in the world. We can see clearly the high frequency services with small-size aircraft in US and Europe whereas the low frequent services with large-size aircraft in Asia especially in Japan.

In order to show how often the airlines in US and Europe utilize the small-size aircrafts in more detail, we count the share of aircraft size used at each route which is broken down into some categories of seat capacity. The data we used is OAG (Official Airline Guide) Flight Schedule data in 2007 January. Figure 2, 3, 4 shows share of each aircraft size category at all domestic route from NY area (JFK, La Guardia (LGA) and Newark (EWR)), all intra-Western Europe routes from London area (Heathrow, Gatwick and Stansted) and all domestic route from Tokyo Haneda respectively. We categorized the routes by available annual seat capacity (less or over 500 thousand seats) and route distance (less than 999km, from 1000 to 1999km, over 2000km). Annual seat capacity is calculated based on daily total seat capacity (one-way daily capacity * 2 * 365). For Japan case, we did not categorize by route distance because most routes from Haneda are less than 1000km.

From these figures, we can see that airlines in US utilize many small-size aircrafts which have less than 100 seats especially on short-distance routes and lower demand routes (the share is

around 70-90 % on the route with less than 500 thousand seats/year and less than 2000km distance). Even on higher demand route, with over 500 thousand seat/year, the share is around 50% on short distance route. These are mostly Regional Jet (RJ) and turbo-prop aircraft. On longer distance routes and on larger demand routes, they utilize mainly medium-size aircrafts which have less than 200 seats. In NY area, there are few large aircrafts over 200 seats.

Aircraft size on the route from London within Western Europe is larger than that in NY, US. They utilize mainly medium-size aircrafts which have less than 200 seats. Unlike in US, the difference by route demand and distance are small, but at large demand (over 500 thousand seat/year) and long distance routes (over 2000km), they utilize large aircrafts which have more than 200 seats. London airports, especially Heathrow and Gatwick, have strong capacity constraint and the routes within Europe are still international flights, although it is open market like domestic. These factors may contribute towards larger aircraft size.

In Japan, as we mentioned above, many large aircrafts are utilized even for domestic routes. The small size aircrafts, with less than 49 seats, are special case for the route serving two small islands, and basically small size aircrafts, with less than 60 seats, are prohibited to enter Haneda.

Next, in order to examine the flight frequency of airlines in detail, we count the frequency of each aircraft size category on each route. Due to the space constraint for this paper, only the flights from the airports in NY metropolitan area and Haneda are shown as examples. Figure 5 shows the results of NY routes. From this figure, we can see that they can provide high-frequency service even on low demand route with small-size aircraft with less than 100 seats. Figure 6 shows the result of Haneda routes. The difference between two countries is very clear. For example, in NY, the frequency is more than 5 flights/day (maximum around 10 flights) on routes with a demand volume of around 500 thousand seats/year. On the other hand, in Japan, it is less than around 3 flights/day.

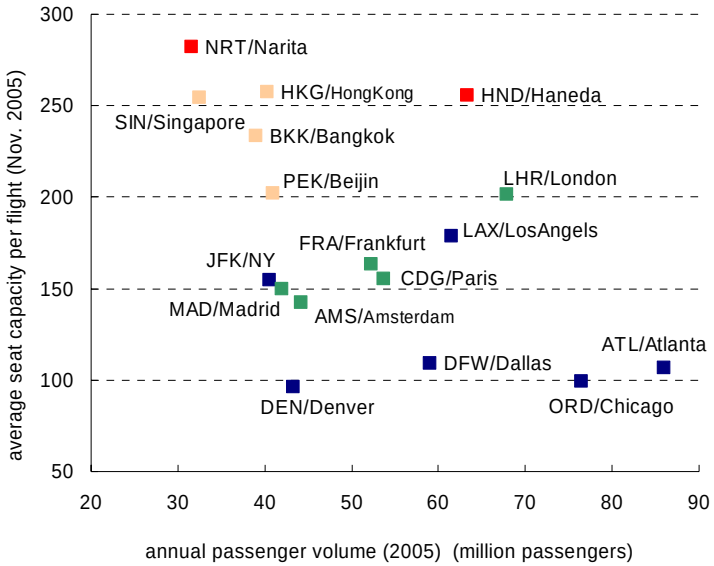

Figure 1 Average seat capacity per flight and annual passenger volume of major airports in the world (seat capacity: OAG November 2005, passenger volume: ACI website)

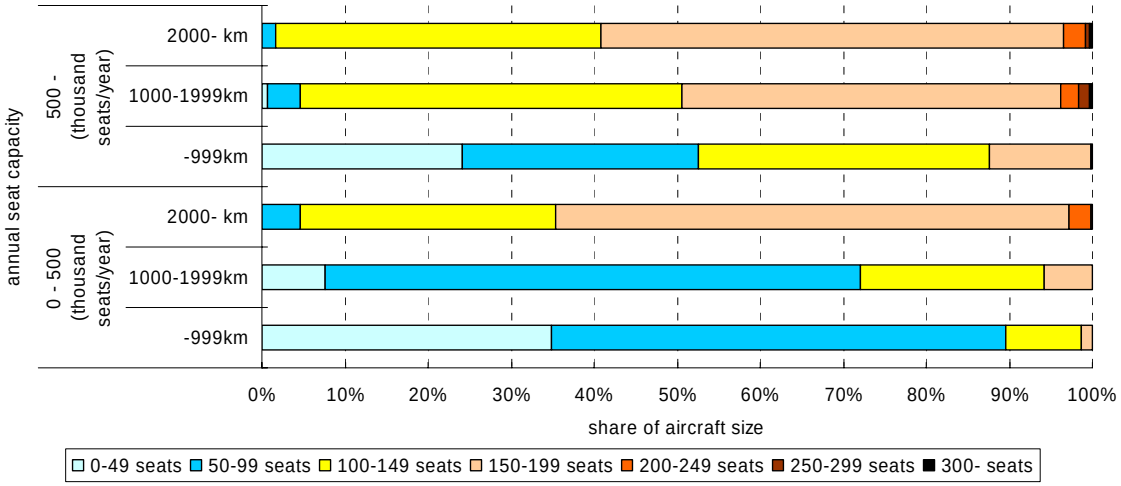

Figure 2 Share of aircraft size at all domestic routes from NY airports (JFK, LGA, EWR) (January 2007)

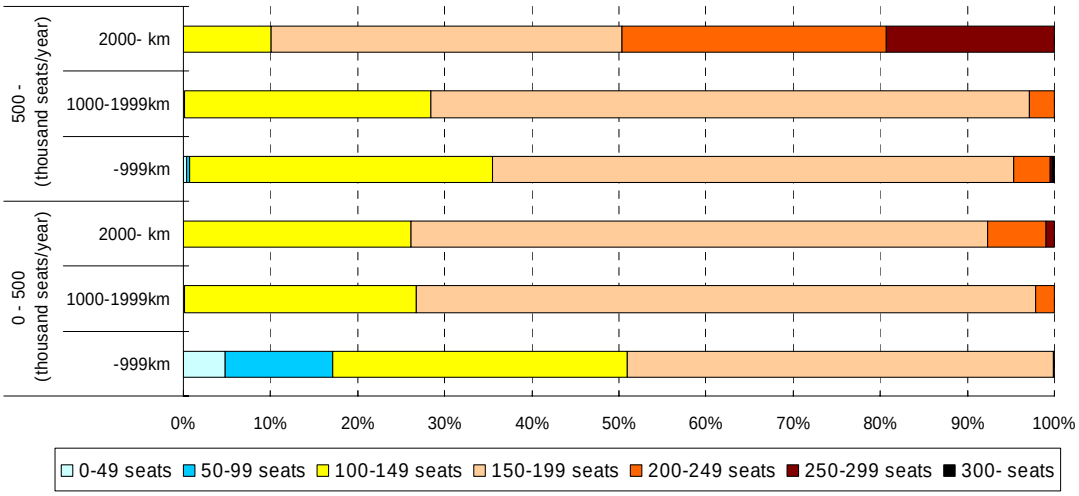

Figure 3 Share of aircraft size at all routes from London airports (LHR, LGW, STN) within Western Europe (January 2007)

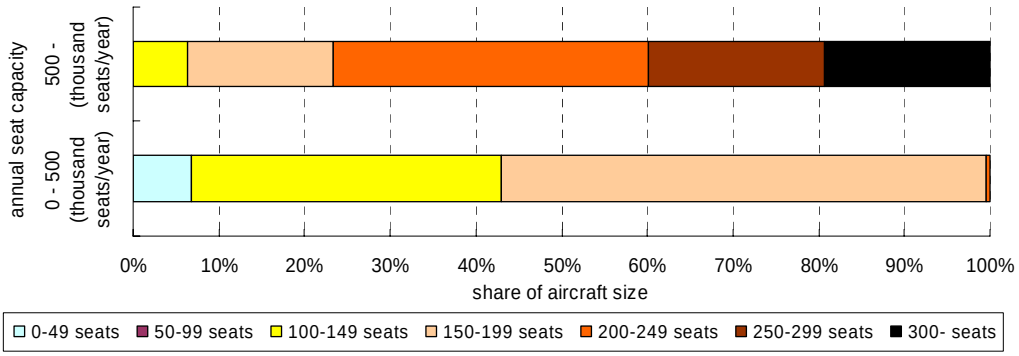

Figure 4 Share of aircraft size at all domestic routes from Haneda airport (January 2007)

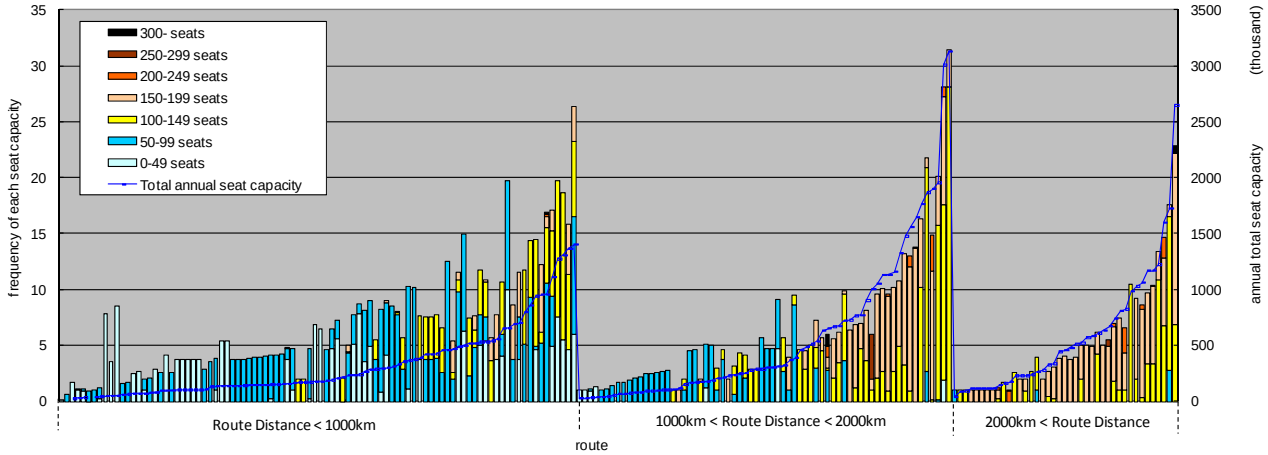

Figure 5 Flight frequency of each domestic route from NY three airports (JFK, LGA, EWR) (January 2007)

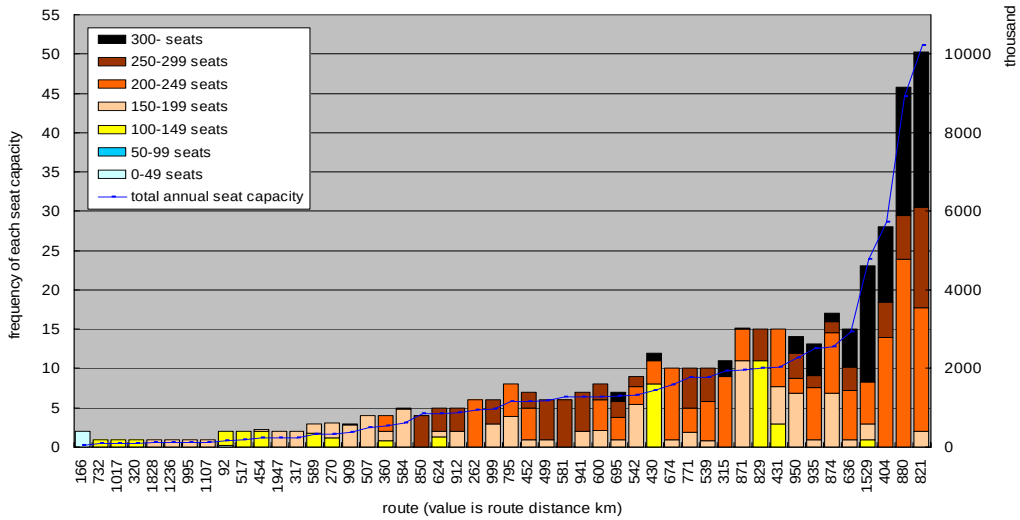

Figure 6 Flight frequency of each domestic route from Haneda (January 2007)

3. COMPARATIVE ANALYSIS OF DOMESTIC PASSENGER FLGIHT FREQUENCY BETWEEN JAPAN AND US AVIATION MARKET

3.1 Factors Affecting the Flight Frequency

Based on Hansen et al (2001), we summarized the several factors that can affect the flight frequency as follows

a) Passenger volume

Airlines accommodate increase of passenger volume by increasing flight frequency or enlarging the aircraft capacity.

b) Route distance

As route distance is longer, flight frequency usually becomes lower and aircraft size becomes larger. This is because the benefit of high frequency for passengers becomes lower for longer-distant route (longer flight time) as the flexibility of choosing departure/arrival time by passengers is lower. Another possible reason is that cost advantage of large-size aircraft is higher at longer distance.

c) Level of competition

Frequency competition may occur among different airlines on multiple track routes (routes

operated by multiple airlines) and they must usually utilize smaller aircraft in order to match smaller number of passengers per airline.
d) Airport capacity constraint
Airport capacity constraint may force airlines to use larger aircraft in order to transport more passengers per flight.
e) Attribute of passenger
Generally business passengers prefer high frequency service and their yield is higher than the passengers with personal trips like leisure purpose, which can make it easier to increase flight frequency with smaller aircraft whose operation cost tends to be higher.

In the next section, we analyze how some of these factors actually affect the flight frequency and aircraft size in Japan and US domestic aviation market.

3.2 Comparative Analysis of Flight Frequency and Aircraft Size between Japan and US

Data for the analysis is "T-100 Domestic Segment Database (Bureau of Transportation Statistics, US)" for US domestic aviation market, and "Annual Statistical Report on Air Transport (Koku-Yuso-Tokei-Nenpou)(Ministry of Land, Infrastructure and Transport, Japan)" for Japan. With these statistics, we can get the data including passenger volume, aircraft seat capacity, frequency, number of operating airlines and route distance of each route. For US data, we selected all routes between the following major airports in terms of total passenger volume; ATL, BOS, BWI, CVG, DCA, DEN, DFW, IAD, JFK, LAS, LAX, LGA, LGB, OAK, ORD, PHX, SEA, SFO, SJC, STL (total 152 routes). For Japan data, we selected all domestic routes (total 225 routes).

Figure 7 and Figure 8 shows the relationship between flight frequency and passenger demand of each route respectively in Japan and US. The pattern in each plot indicates the category of route distance (see the legend in the Figure). Figure 9 and Figure 10 shows the relationship between average seat capacity per flight and daily passenger volume respectively in Japan and US. Here, the four routes in Japan are not shown in the figure (Haneda- Sapporo, Fukuoka, Osaka, Naha) as they had much larger annual passenger demand by comparing with the other routes in Japan and US. Both in Japan and US, flight frequency is higher as passenger volume is larger, and flight frequency is lower as the route distance is longer as usually expected. Roughly comparing the difference of flight frequency between in two countries, we can see that flight frequency on the route with more than 500km distance is much lower in Japan than in US while its difference is not large for the route with not more than 500km. This indicates that Japanese airlines have accommodated the increase of passenger volume by using aircraft with larger capacity. On the other hand, US airlines have accommodated the increase of passenger volume by increasing flight frequency without changing seat capacity per flight (relatively smaller aircraft). We can see such trends also in Figure 9 and Figure 10 that show the aircraft size used in each route. From these figures, Japanese airlines have been forced to use large aircrafts with over 200 seats even on low demand routes while US airlines have utilized the aircrafts with less than 200 seats even on high demand and long distance routes. In US, airlines often use the smaller size aircraft with less than 100 seats together with medium size aircrafts on lower demand route (500-2000 pax/day) offering higher frequency services. The capacity constraint of Haneda airport is the main responsible factor for the seemingly inefficient situation of Japanese domestic aviation as mentioned above.

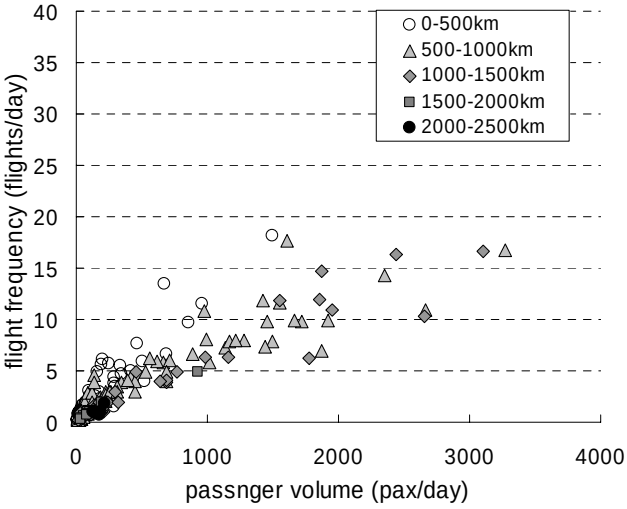

Figure 7 Flight frequency and passenger volume in Japan (2004)

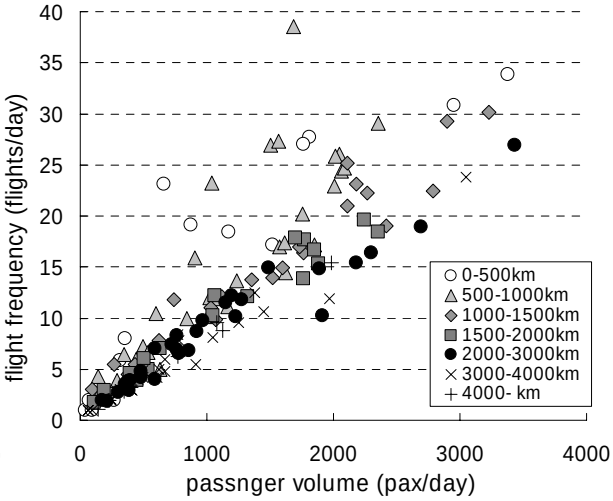

Figure 8 Flight frequency and passenger volume in US (2004)

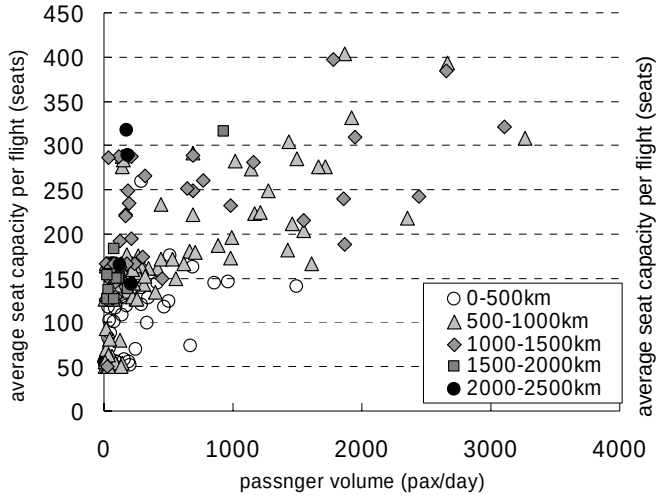

Figure 9 Average seat capacity per flight and passenger volume in Japan (2004)

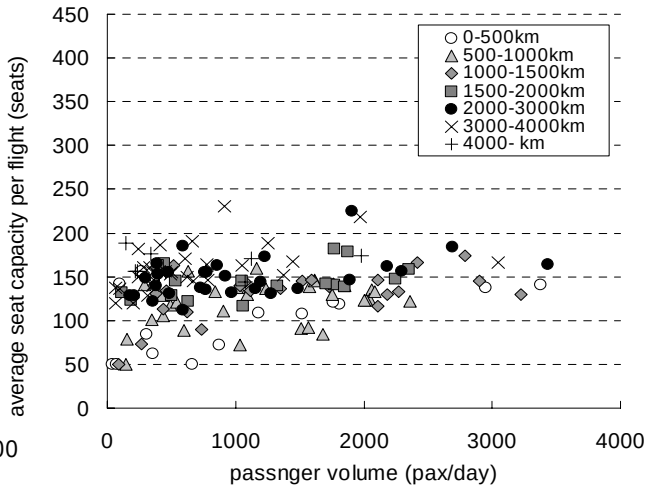

Figure 10 Average seat capacity per flight and passenger volume in US (2004)

Figure 11 and Figure 12 show the relationship between flight frequency and number of operating airlines in Japan and US respectively. As more airlines enter the route, the flight frequency tends to increase. This may be the effect of the competition among airlines. And more airlines have entered the market in US than in Japan. Figure 13 shows the histogram of annual average of Load Factor (LF = passenger volume / seat capacity) in Japan and US. LFs are much higher in US (total average: 71.4%) than in Japan (total average: 57.6%; Haneda-route average 64.2%). Since Japanese airlines have used mainly larger aircrafts due to the airport capacity constraint as mentioned above, they might have faced more difficulty in terms of flexibly adjusting seat-capacity of each flight with respect to changing passenger volume.

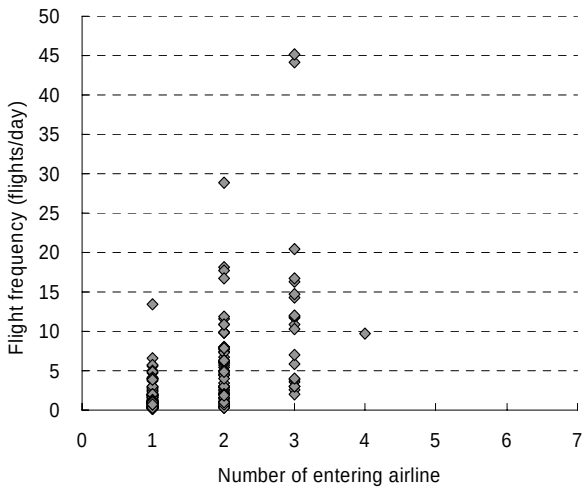

Figure 11 Flight frequency and number of entering airline in Japan (2004)

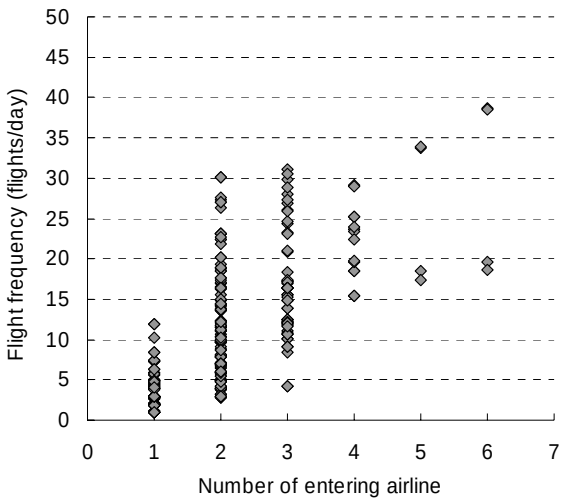

Figure 12 Flight frequency and number of entering airline in US (2004)

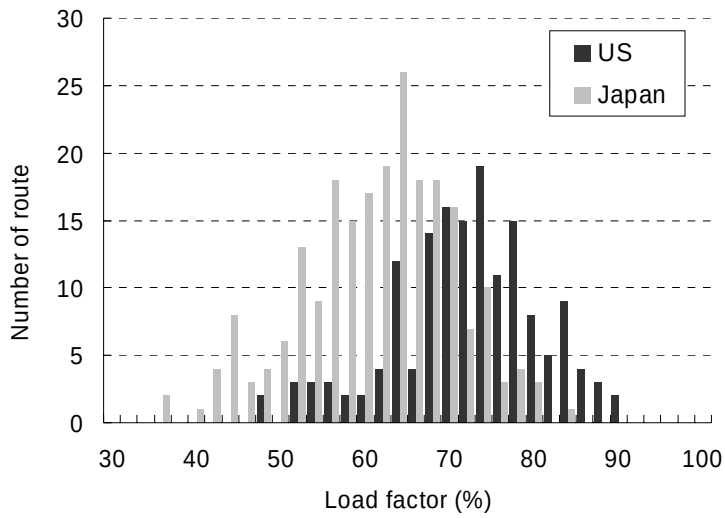

Figure 13 Histogram of Load Factor in Japan and US

In the previous sections, we looked at the relationship between flight frequency and each of several factors one by one. In this section, we examine the statistical relationship between flight frequencies and some of these several factors by the simple regression model as shown in equation (1). Estimation results of the regression model for US and Japanese market are shown in Table 1 and Table 2 respectively. By this model, we can see that passenger volume and route distance are statistically significant determinants of flight frequency as well as number of operating airlines as an index of competition level. And if we compare the two results of the estimation, we can see that, as passenger volume increases, flight frequency in US increases more significantly than in Japan. This indicates higher frequency in US than in Japan even when some structural market characteristics are controlled.

$$Freq_i = \alpha + \sum_k \beta^k X_i^k + \varepsilon_i \tag{1}$$

$Freq_i$: Flight frequency of route i (flights / day)

X_i^k : Attribute k of route i

β^k : Parameter of Attribute k

Table 1 Estimation results of regression model for flight frequency in US

X^k	β^k (t-stat)
passenger volume (pax/day)	$1.94 * 10^{-2}$ (10.8)
Ln (route distance) (km)	-1.26 (-4.04)
number of entering airlines per route	1.78 (9.15)
passenger volume * Ln (route distance)	$-1.68 * 10^{-3}$ (-6.88)
constant	8.92 (3.77)
	adjusted R^2=0.90

Table 2 Estimation results of regression model for flight frequency in Japan

X^k	β^k (t-stat)
passenger volume (pax/day)	$0.62*10^{-2}$ （3.48）
Ln (route distance) (km)	-0.89 （-3.49）
number of entering airlines per route	1.39 （6.92）
passenger volume * Ln (route distance)	$-0.39*10^{-3}$ (-1.48)
constant	5.60 （3.49）
	adjusted R^2=0.88

In order to see how low the frequency of each of the routes to/from Haneda airport are in comparison with the level of service in US market, we estimate the flight frequencies by using the equation (1) with the parameter for US market (Table 1) and with the input data of passenger volume, route distance, number of entering airline in Japan. The result shows in Figure 14. All of the estimated frequencies by US model are higher than the actual frequencies of Haneda route in 2004. These differences can be one of the values as a reference for us when we consider the potential flight frequency at the routes to/from Haneda airport without capacity constraint. If we count up all of the differences, the total is around 200 flights per day. If we count up the differences of only business route (assuming the route where more than 50% of all passengers are business passenger: see Figure 14), the total is still around 150 flights per day. To take an example of the difference, it is relatively bigger on Hakodate route. This can be explained by low percentage of business passenger, which makes airlines try to reduce the cost per seat with larger aircrafts due to the low yield of non-business passenger. Hakodate city is one of the major sightseeing spot in Japan. On the other hand, the routes like Komatsu and Takamatsu where the difference is relatively bigger and percentage of business passenger is relatively higher have a higher potential flight frequency. Toyama route is also the case of high percentage of business passengers. However, Toyama airport has a capacity constraint due to noise problem, therefore the noise mitigation measures including utilization of the low-noise small-size aircrafts are also needed to increase flights. Here, we do not count up the frequencies at Naha, Osaka, Shin-Chitose and Fukuoka. As for the estimated frequencies of these routes, there might be problem about the validity because

the passenger demands at these routes are much higher than the other routes in Japan and US. And actually, the saturated frequency at a specific route is said to be around 60 flights at the highest (Aibus (2004)). The increase of the slot for domestic flights by the expansion of Haneda airport in 2010 will be around 80 slots per day. Therefore the increase of the slot at Haneda will be insufficient for attaining the same level of service in terms of flight frequency as in US. If we consider the change of the number of operating airlines to each route by new entries and/or open of new routes etc, the slot increase will be more insufficient. A note of caution is in order here; this is not an analysis by modeling the behaviors of airlines and passengers in Japan but comparative analysis between the actual flight frequencies in US and in Japan. Therefore, whether Japanese airlines will increase frequency as much as the level in US like the estimation above is not certain because the cost structure of Japanese airlines or the competitive environment with other mode like high-speed rail might be different between two countries. However the high level of service in terms of flight frequency in US, or in Europe also, is the fact. That indicates there is a possibility to achieve the high frequency services in Japan. So we think that it is important to consider continuously the capacity expansions in Tokyo metropolitan area also after the Haneda expansion in 2010. And if there is insignificant change in domestic flight frequency even after the capacity expansion of Haneda airport, we need to consider the underlying causes of such a situation and countermeasures including further deregulation policies may be further needed.

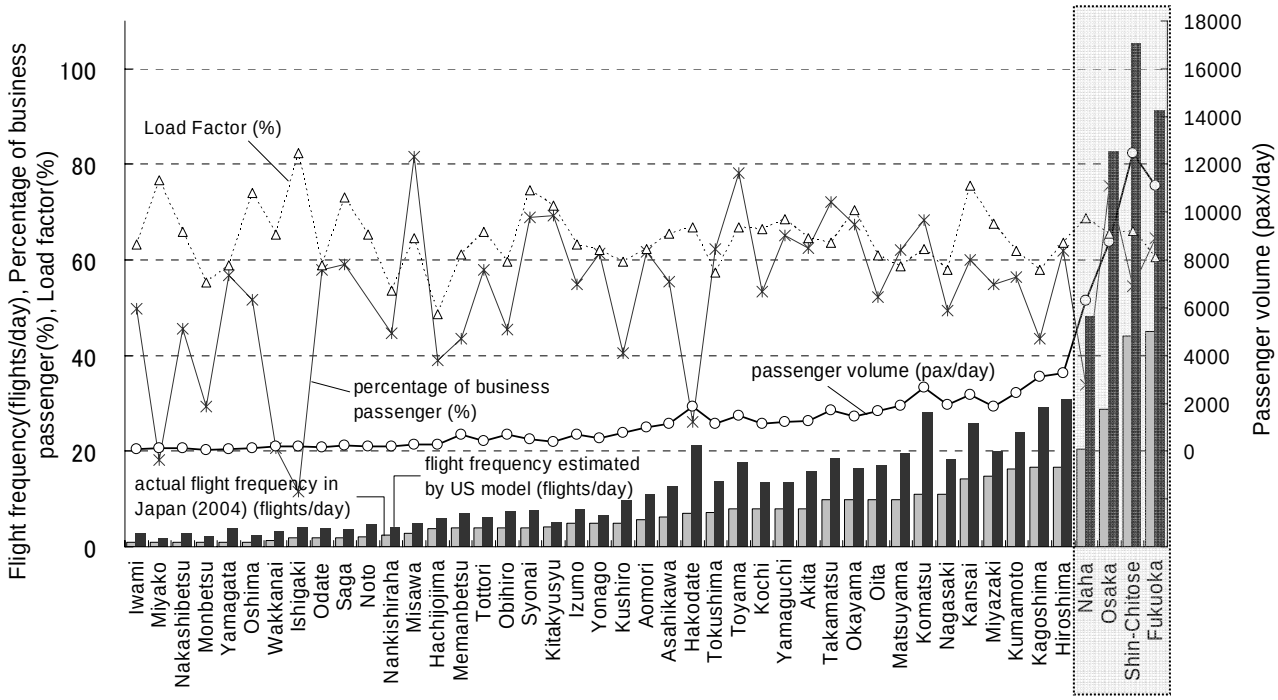

Figure 14 Result of applying the regression model for US market to Haneda routes

4. CONCLUSIONS

In this study, first, we made a broad comparision between the flight frequencies and aircraft sizes among major airports in the selected metropolitan area worldwide, and discussed some examples of utilization of small-size aircraft like Regional Jets for increasing flight frequency and for efficiently serving varying passenger demand in a flexible way. As is often said,

aircrafts used in Japan, especially on Haneda routes, are unusually large (over double size of that in US and European countries). Consequently many routes have had low frequency services so far. Second, in order to get an idea on the potentially feasible or desirable flight frequency, we analyzed the flight frequency in US and Japan taking into account the key characteristics of each air route such as passenger demand, route distance and number of operating airlines. If we assume the frequent service on all Haneda routes to be at the same level as on corresponding US routes, the total additional flight frequency will be much more than the increase of slots by Haneda expansion in 2010. After the Haneda expansion there will be still many issues to be considered such as the necessity and possibility for expanding more capacity at Haneda, how to allocate the slots not only for domestic flights but also for international flights, and further deregulation policies in the worldwide era of open-sky policies. For such considerations, it is important to study and assess the potential demand as well as capacity in the future. The result of this study is just one set of estimated value for possible reference when we consider the potential flight frequency in Haneda routes, and further surveys and researches are still needed including the estimation by a model which can directly analyze the behaviors of airlines and passengers.

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