THE COMPETITIVE POSITION OF TOKYO INTERNATIONAL AIRPORT BEFORE AND AFTER OPENING SCHEDULED INTERNATIONAL SERVICES

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Abstract: Tokyo International Airport (Haneda) is one of the two primary airports serving the Greater Tokyo Area, handling almost all domestic flights to/from Tokyo. In recent years, however, international services from Haneda have expanded significantly with the addition of "scheduled charter" flights, and the Japanese government plans to expand Haneda's international role after its expansion in October 2010. The main purpose of this paper is to evaluate the effects of opening scheduled international services at Haneda on its hub competitive position. After providing the development schemes and outline of Haneda, this paper estimates the route choice probabilities and transfer passenger market shares at major hub airports with regard to passengers departing from Japan in September 2010 and in March 2011 by the NetCost model, which evaluates the quality of airline networks. The results reveal that after the opening of scheduled international services at Haneda in October 2010, its transfer passenger market shares remarkably increase in the markets between Japan and Asia & Oceania, between Japan and North America and between Japan and World (excluding Japan), greatly owing to quite a lot of incoming domestic flights to Haneda connecting well to the newly started international flights outgoing to Asia & Oceania, Europe and North America. Meanwhile, Seoul/Incheon is a dominant hub in all markets except between Japan and Latin America and between Japan and Africa in March 2011, largely because of the strategic well-developed hub-and-spoke networks by Korean air carriers to Japan.

Key Words: NetCost Model; Route Choice Probabilities; Transfer Passenger Market Shares and Tokyo International Airport (Haneda)

JEL-code: L93

1. INTRODUCTION

Tokyo International Airport, commonly known as Haneda, is one of the two primary airports serving the Greater Tokyo Area. Although Haneda originally used to be the primary airport for the Tokyo region, it now shares that role with Narita International Airport (Narita). Haneda handles almost all domestic flights to/from Tokyo, while Narita handles almost all international flights. In recent years, however, international services from Haneda have expanded significantly with the addition of "scheduled charter" flights to Seoul/Gimpo (in 2003), Shanghai/Hongqiao (in 2007), Hong Kong (in 2008) and Beijing/Capital (in 2009). The Japanese government plans to expand Haneda's international role after its expansion in October 2010. The main purpose of this paper is to evaluate the effects of opening scheduled international services at Haneda on its hub competitive position.

In Asia, airline networks are progressively transforming into hub-and-spoke networks, as international aviation markets become increasingly liberalized. Meanwhile, formation of global airline alliances strongly stimulates these network configurations. Typical examples are the strategic network developments by Korean air carriers (Korean Air and Asiana Airlines), especially to Japanese (and Chinese) local airports. Their network developments affect Japanese air carriers and Japanese economy. In August 2007, Japanese and Korean governments reached an open-skies agreement except at the most congested airports in Tokyo and Seoul (Tokyo/Narita, Tokyo/Haneda, Seoul/Incheon and Seoul/Gimpo). As a result, air carriers on both sides can freely open routes or increase frequencies.

After providing the development schemes and outline of Haneda, this paper estimates the route choice probabilities and transfer passenger market shares at major hub airports with regard to passengers departing from Japan in September 2010 and in March 2011 by the NetCost model. The NetCost model evaluates the quality of airline networks by translating airline network data into indicators expressing the attractiveness of a particular connection for passengers. For each relevant connection, direct as well as indirect, the model determines the generalized travel costs, being a representation of all inconveniences passengers are confronted with at a specific connection. Generalized travel costs include not only airfares, but also the perceived costs of travel time and waiting time for the next flight. These costs are translated into the relevant network indicators, consumer values, expressing the perceived value for passengers, which determine the route choice probabilities and transfer passenger market shares. The model allows a comparison of network quality and market shares among several competing airports or airlines, as well as a monitoring of network quality and market shares of particular airports or airlines over time.

Finally, the results will be expected to evaluate the effects of opening scheduled international services at Haneda on its hub competitive position, which will be useful for the assessment of network performance and hub competitive position among competing airports in Northeast Asia.

2. DEVELOPMENT SCHEMES AND OUTLINE OF TOKYO INTERNATIONAL AIRPORT

2.1 Historical Backgrounds

Table 1 shows the historical backgrounds of Haneda up to now.

Table 1. Historical Backgrounds of Haneda

Year	Development or Expansion Schemes
1931	Haneda first opened as Haneda Airfield, 53 hectare with one 300m runway.
1939	The runway was extended to 800m and a second 800m runway was completed.
1945	U.S. occupation forces took over the airport and renamed it Haneda Army Air Base. The Army proceeded with various construction projects, including extending one runway to 1,650m and the other to 2,100m.
1952	The U.S. military gave part of the base back to Japan.
1958	The remainder was returned to the Japanese government.
1970	A new runway (third runway) and an international terminal were completed.
1978	New Tokyo International Airport (Narita) opened, taking over almost all international services in the Tokyo region, and Haneda practically became a domestic airport.
1978-2002	While most international flights moved from Haneda to Narita in 1978, airlines based on Taiwan (CAL and EVA) continued to use Haneda.
1984-2007	A large-scale landfill project in Tokyo Bay was proceeded for Haneda's expansion.
1988	A-Runway was moved from the initial place to the landfill area and extended.
1993	The old airport terminal was replaced by a new West Passenger Terminal built on the landfill area.
1997	C-runway was moved and extended on the landfill area.
2000	B-runway was moved and extended on the landfill area.
2003-	International scheduled charter services started to Seoul/Gimpo (in 2003), Shanghai/Hongqiao (in 2007), Hong Kong (in 2008) and Beijing/Capital (in 2009).
2004	Terminal 2 opened for ANA, ADO, SNA and SFJ, and Terminal 1 built in 1993 became the base for JAL, SKY and SFJ.
Now	The fourth runway (D-runway), a third terminal for international flights and an international air cargo facility are under construction.
	The Japanese government is under negotiations with those in twelve countries/region.

Haneda first opened in 1931 as Haneda Airfield on a small piece of bay front land at the south end of today's airport complex. Its initial area was 53 hectare with one 300m runway. In 1939, this airport's first runway was extended to 800m and a second 800m runway was completed.

In 1945, U.S. occupation forces took over the airport and renamed it Haneda Army Air Base. The Army proceeded with various construction projects, including extending one runway to 1,650m and the other to 2,100m. The U.S. military gave part of the base back to Japan in 1952. This portion became known as Tokyo International Airport. The US military maintained a base at Haneda until 1958 when the remainder of the property was returned to the Japanese government.

With the rapid replacement of propeller-powered aircrafts with jet aircrafts, a new runway and an international terminal were completed in 1970, which made the present Haneda's original form with three runways. Demand, however, continued to outpace expansion. The government anticipated this growth in the early 1960's and believed that further expansion of Haneda would be impractical due to the cost and technical issues inherent in a large-scale landfill project in Tokyo Bay. Instead, a plan was put forward to build a new airport to handle international flights in the Tokyo region. In 1978, New Tokyo International Airport (now renamed as Narita International Airport) opened, taking over almost all international services in the Greater Tokyo Area, and Haneda practically became a domestic airport.

Since demand continued to increase, beyond its capacity, with the arrival of mass transportation age by large-sized and fast aircrafts, the government decided to proceed a large-scale landfill project in Tokyo Bay between 1984 and 2007. This project was also put forward with increasing social concerns on aircraft noise and environment. In July 1988, A-runway was moved from the initial place to the landfill area and extended. In September 1993, the old airport terminal was replaced by a new West Passenger Terminal, which was built farther out on the landfill. C-runway and B-runway were also moved and extended on the landfill area in March 1997 and in March 2000, respectively. In 2004, Terminal 2 opened for All Nippon Airways (ANA), Hokkaido International Airlines (ADO), Skynet Asia Airways (SNA) and Star Flyer (SFJ), and the one newly built in 1993, now known as Terminal 1, became the base for Japan Airlines (JAL), Skymark Airlines (SKY) and SFJ.

While most international flights moved from Haneda to Narita in 1978, airlines based on Taiwan continued to use Haneda for many years due to the ongoing political conflict between the Republic of China and the People’s Republic of China. China Airlines (CAL) served Taipei and Honolulu from Haneda. Taiwan's second major airline, Eva Airways (EVA), joined CAL at Haneda in 1989. All Taiwan flights, however, were moved to Narita in 2002 when the second runway provisionally opened at Narita. In recent years, international services from Haneda have expanded significantly with the addition of “scheduled charter” flights to Seoul/Gimpo (in 2003), Shanghai/Hongqiao (in 2007), Hong Kong (in 2008) and Beijing/Capital (in 2009). The Japanese government plans to expand Haneda's international role after its expansion in October 2010, and additional city-to-city services, such as between Haneda and Taipei/Songshan, are scheduled to commence on the 31st of October, 2010. As of September 2010, the Japanese government reached the agreements with those in twelve countries/region; six countries/region in Asia & Oceania (Korea, China, Taiwan, Thailand, Malaysia and Singapore), four countries in Europe (UK, France, Germany and the Netherlands) and two countries in North America (US and Canada). Some governments have already announced their flight schedules.

2.2 Development Schemes under Way and Future Outline

The fourth runway, which is called D-runway, is scheduled to be in use on the 21st of October in 2010 to the south of the existing airfield as shown in Figure 1. Figure 2 and Figure 3 describe its latest aerial photo of D-runway and the image of its completion, respectively. This runway is expected to increase its operational capacity from 303 thousand movements to 407 thousand movements per year, permitting the increase on frequencies of existing routes, as well as the opening of new routes. Meanwhile, a third terminal for international flights is planned to be in use at the end of October 2010 as well (See Figure 4-1 and Figure 4-2). The cost to construct the five-story international passenger terminal building and attached 2,300 car parking deck will be covered by a Private Finance Initiative process, revenues from duty-free concessions and a facility use charge of 2,000 yen per passenger. An international air cargo facility will also be constructed nearby (See Figure 5).

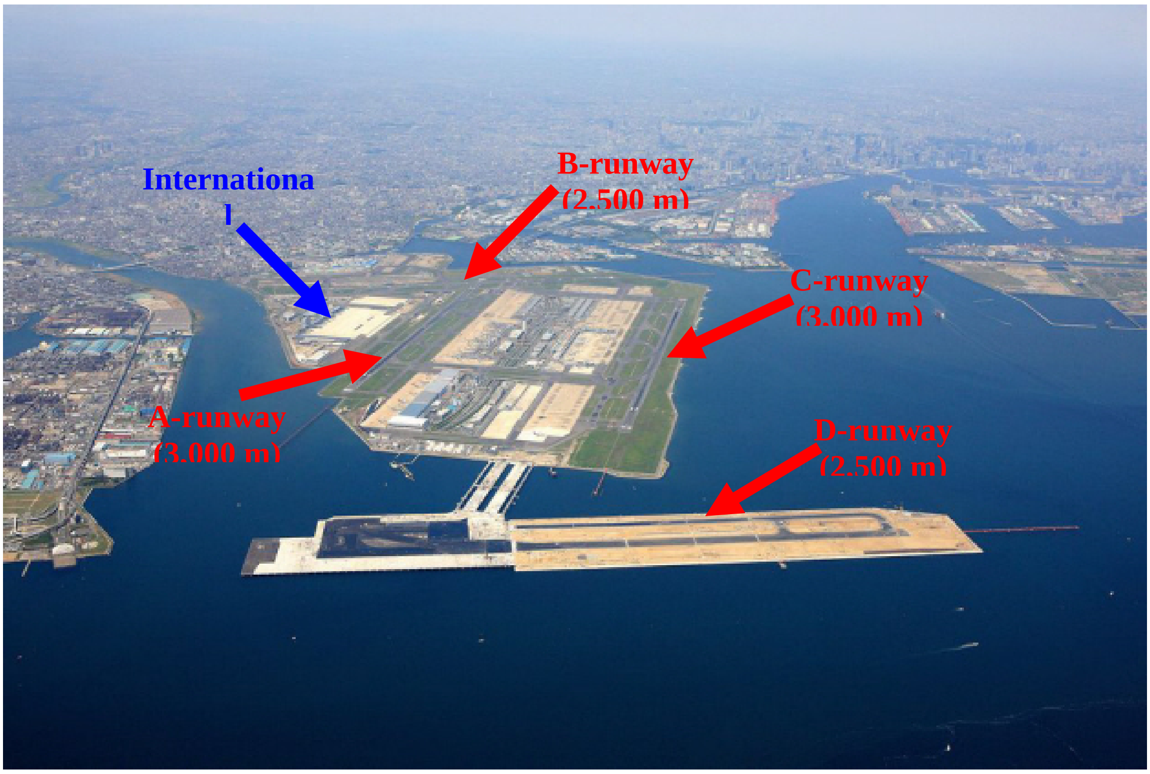

Figure 1. Aerial Photo of Haneda, as of the 8th of May, 2010

Source: Ministry of Land, Infrastructure, Transport and Tourism

Figure 2. Aerial Photo of D-runway, as of the 29th of September, 2010

Source: TAKEICHI, Kimitaka

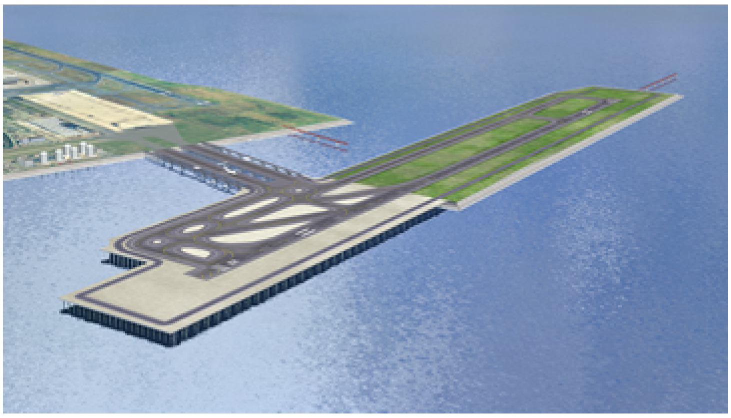

Figure 3. Image of D-runway

Sources: Joint Venture for D-runway Construction of Haneda

Figure 4-1. Image of International Passenger Terminal (No.1)

Source: Tokyo International Air Terminal Corporation

Figure 4-2. Image of International Passenger Terminal (No.2)

Source: Tokyo International Air Terminal Corporation

Figure 5. Image of International Cargo Terminal

Source: Tokyo International Air Cargo Terminal Ltd.

In particular, Haneda will offer additional slots to handle 60 thousand overseas flights a year (30 thousand during the day and another 30 thousand during late night and early morning hours), which means 40 flights each, 80 flights in all per day. The Ministry of Land, Infrastructure, Transport and Tourism originally planned to allocate a number of the newly available landing slots to international flights of 1,947 km or less (the distance to Ishigaki, the longest domestic flight operating from Haneda). The destinations within this range include all of Korea, parts of eastern and northern China (including Shanghai, Qingdao, Dalian, Harbin and Beijing) and parts of the Russian Far East (including Vladivostok and Sakhalin).

In June 2007, Haneda gained the right to host international flights that depart between 8:30 p.m. and 11:00 p.m. and arrive between 6 a.m. and 8:30 a.m. In May 2008, a further liberalization was announced, allowing flights to any destination to operate between 11 p.m. and 6 a.m., when Narita is closed.

Table 2 summarizes the outline of Haneda as of October 2010 and its traffic statistics in 2009.

Table 2. Outline and Traffic Statistics of Haneda

Year	As of October, 2010		
Area (ha)	1,421		
Number of Runways	A : 3,000m×60m, B : 2,500m×60m, C : 3,000m×60m, D : 2,500m×60m		
Maximum Aircraft Movements (,000)	407 (60 for international services) in 2010 → 447 (90 for international services) in 2013		
	Domestic	International	Total
Number of Destinations	48*	17*	65*
Number of Flights (per day)	3,258* (465*)	353* (50*)	3,611* (515*)
Passenger Terminal (,000 ㎡)	Terminal 1 (290.0), Terminal 2 (205.2)	159.0	654.2
Cargo Terminal (,000 ㎡)	70.7 (East Side + West Side)	Terminal 1 (34.5), Terminal 2 (18.3), Other (3.1)	126.6
Passenger Volume (,000)	59,314**	2,590**	61,904**
Cargo Volume (,000 ton)	709.6**	11.9**	721.5**

Notes: * means the numbers in the third week of March, 2011.

** means the up-to-the-minute numbers in 2009.

Source: Civil Aviation Bureau, Ministry of Land, Infrastructure, Transport and Tourism

2.3 Air Traffic Statistics

Haneda handled 66.8 million passengers in 2008 (Domestic: 64.4 million, International: 2.4 million). By passenger throughput, it was the busiest airport in Asia and the fourth busiest in the world, after Atlanta/Hartsfield-Jackson (90.0 million), Chicago/O'Hare (69.4 million) and London/Heathrow (67.1 million), according to Airports Council International (ACI). It is the primary base of Japan's two major airlines, JAL and ANA, as well as low-cost carriers, ADO, SKY, SNA and SFJ. It is forecasted Haneda will handle 70.8 million passengers in 2012 (see Table 3).

Table 3. Forecast of Passenger Volumes at Haneda and Narita, 2010-2012

Airport	Category	2009	2010	2011	2012
Haneda	Domestic	59,300	61,000	61,600	62,200
	International	**2,600**	**5,000**	**8,000**	**8,600**
	Total	61,900	66,000	69,600	70,800
Narita	Total	29,700	33,100	33,800	34,500

Notes: Fiscal year.

The numbers in 2009 are up-to-the-minute.

Source: Japan Airport Terminal Co.,Ltd. and Narita International Airport Corporation

Table 4 shows the split-up of the number of flights in the third week of March, 2011 in Table 2. There are 353 flights to seventeen international destinations, including of Seoul/Gimpo (70 flights), Taipei/Sung Shan (56 flights), Hong Kong (35 flights), Beijing/Capital (28 flights), Shanghai/Hongqiao (28 flights) and Singapore/Changi (28 flights). Out of 3,258 domestic flights with forty-eight destinations, 1,227 flights are to twelve airports in Kyūshū. Among them are Fukuoka (329 flights), Kita Kyushu (181 flights), Naha (Okinawa) (171 flights), Kagoshima (119 flights), Kumamoto (112 flights) and Miyazaki (105 flights), all of which are over 100 flights per week. Nine airports in Hokkaidō are connected with Haneda, out of which Sapporo/Chitose with 427 flights per week is its biggest market. As for other airports, Osaka/Itami and Osaka/Kansai in Kansai region are over 100 flights in this week.

Table 4. Split-up of Number of Destinations and Flights by Regions at Haneda in the third week of March, 2011

Hokkaidō		Tōhoku region		Kantō region		Chūbu region		Kansai region	
Airport	No. of Flights	Airport	No. of Flights	Airport	No. of Flights	Airport	No. of Flights	Airport	No. of Flights
Sapporo/Chitose	**427**	Akita	49	Hachijo Jima	21	Komatsu	77	**Osaka/Itami**	**203**
Asahikawa	84	Aomori	42	Miyake Jima	7	Toyama	42	**Osaka/Kansai**	**134**
Hakodate	63	Shonai	28	Oshima	7	Wajima	14	Kobe	70
Memanbetsu	49	Misawa	21					Nanki Shirahama	21
Kushiro	35	Odate Noshiro	14						
Obihiro	28	Yamagata	7						
Wakkanai	7								
Monbetsu	7								
Nakashibetsu	7								
Total	707	Total	161	Total	35	Total	133	Total	428
Chūgoku region		Shikoku		Kyūshū		International Destinations			Grand Total
Airport	No. of Flights	Airport	No. of Flights	Airport	No. of Flights	Airport		No. of Flights	
Hiroshima/Intl	98	Matsuyama	77	**Fukuoka**	**329**	Seoul(Gimpo Intl)		70	Domestic
Okayama	63	Takamatsu	70	**Kita Kyushu**	**181**	Beijing(Capital)		28	
Ube	56	Kochi	56	**Naha (Okinawa)**	**171**	Shanghai (Hongqiao Intl)		28	
Izumo	35	Tokushima	42	**Kagoshima**	**119**	Hong Kong(Intl)		35	
Yonago	35			**Kumamoto**	**112**	Taipei(Sung Shan)		56	3,258
Tottori	28			**Miyazaki**	**105**	Kuala Lumpur(Intl)		7	
Iwami	7			Nagasaki	84	Kota Kinabalu		3	
				Oita	77	Bangkok (Intl)		21	
				Saga	28	Singapore(Changi)		28	
				Amami O Shima	7	Honolulu		21	International
				Ishigaki	7	London(Heathrow)		7	
				Miyako Jima	7	Paris(Charles De Gaulle)		7	
						New York(Kennedy)		7	
						Los Angeles(Intl)		14	353
						San Francisco(Intl)		7	
						Detroit(Metro Wayne)		7	
						Vancouver(Intl)		7	
Total	322	Total	245	Total	1,227	Total		353	3,611

Note: Hokkaidō (the island of Hokkaidō and nearby islands), Tōhoku region (northern Honshū), Kantō region (eastern Honshū), Chūbu region (central Honshū), Kansai region (west-central Honshū), Chūgoku region (western Honshū), Shikoku (island), Kyūshū (island, which includes Ryukyu Islands, including Okinawa)

Haneda is the biggest air transportation hub in Japan and domestic air traffic concentrates at Haneda. Table 5 and Table 6 depict these situations from the viewpoint of passenger and cargo flows, respectively. There are twenty-eight airports in Japan with annual traffic volume over one million passengers in 2009, among which twenty-four airports are connected with Haneda. The average share of Haneda-route at these airports is over 50 %. Some of them hit much higher ratio of 70 or 80 %. The case is the same with cargo flows. There are 22 airports in Japan with annual traffic volume over ten thousand tons of cargo in 2009, among which eighteen airports are connected with Haneda. The average share of Haneda-route at these airports is approximately 63 %. Some of them hit much higher ratio of around 90 %.

Table 5. List of Airports in Japan with Annual Traffic Volume over One Million Passengers in 2009

Rank	Airport	Passenger Volumes (departing+arriving) in thousands					Airport Category
		International	Domestic	(to/from Haneda)	Ratio	Total	
1	Tokyo/Haneda	2,590	59,314	—	—	61,904	Class Ⅰ
2	Tokyo/Narita	27,946	1,240	—	—	29,186	Class Ⅰ
3	Sapporo/Chitose	795	15,743	9,026	57.3%	16,538	Class Ⅱ-A
4	Fukuoka	1,991	13,911	7,509	54.0%	15,902	Class Ⅱ-A
5	Osaka/Itami	0	14,563	5,250	36.1%	14,563	Class Ⅰ
6	Okinawa/Naha	286	13,738	5,117	37.2%	14,024	Class Ⅱ-A
7	Osaka/Kansai	9,183	4,097	1,275	31.1%	13,280	Class Ⅰ
8	Nagoya/Chubu	4,152	5,027	—	—	9,179	Class Ⅰ
9	Kagoshima	68	4,980	2,157	43.3%	5,048	Class Ⅱ-A
10	Kumamoto	33	2,819	1,718	60.9%	2,852	Class Ⅱ-A
11	Hiroshima/Intl	297	2,548	2,033	79.8%	2,845	Class Ⅱ-A
12	Sendai	238	2,561	—	—	2,799	Class Ⅱ-A
13	Miyazaki	44	2,666	1,316	49.4%	2,710	Class Ⅱ-A
14	Matsuyama	52	2,314	1,355	58.6%	2,366	Class Ⅱ-A
15	Nagasaki	35	2,305	1,383	60.0%	2,340	Class Ⅱ-A
16	Kobe	0	2,331	1,004	43.1%	2,331	Class Ⅲ
17	Komatsu	90	2,011	1,518	75.5%	2,101	Joint-use Aerodromes
18	Ishigaki	9	1,747	97	5.6%	1,756	Class Ⅲ
19	Oita	23	1,528	1,073	70.2%	1,551	Class Ⅱ-A
20	Hakodate	68	1,436	1,040	72.4%	1,504	Class Ⅱ-A
21	Takamatsu	39	1,329	1,143	86.0%	1,368	Class Ⅱ-A
22	Okayama	206	1,129	878	77.8%	1,335	Class Ⅲ
23	Kochi	4	1,190	750	63.0%	1,194	Class Ⅱ-A
24	Asahikawa	42	1,144	935	81.7%	1,186	Class Ⅱ-B
25	Kita Kyushu	33	1,126	1,006	89.3%	1,159	Class Ⅱ-A
26	Akita	37	1,057	710	67.2%	1,094	Class Ⅱ-B
27	Aomori	40	1,014	633	62.4%	1,054	Class Ⅲ
28	Miyako Jima	1	1,049	105	10.0%	1,050	Class Ⅲ
Average					50.1%		

Source: Civil Aviation Bureau, Ministry of Land, Infrastructure, Transport and Tourism

Table 6. List of Airports in Japan with Annual Traffic Volume over Ten Thousand Tons of Cargo in 2009

Rank	Airport	Cargo Volumes (departing+arriving) in thousand tons					Airport Category
		International	Domestic	(to/from Haneda)	Ratio	Total	
1	Tokyo/Narita	1,809.5	3.2	—	—	1,812.7	Class Ⅰ
2	Tokyo/Haneda	11.9	709.6	—	—	721.5	Class Ⅰ
3	Osaka/Kansai	545.8	41.5	6.9	16.6%	587.3	Class Ⅰ
4	Okinawa/Naha	22.7	225.6	110.9	49.2%	248.3	Class Ⅱ-A
5	Fukuoka	45.0	189.6	139.3	73.5%	234.6	Class Ⅱ-A
6	Sapporo/Chitose	3.1	220.9	173.8	78.7%	224.0	Class Ⅱ-A
7	Nagoya/Chubu	108.5	35.7	—	—	144.2	Class Ⅰ
8	Osaka/Itami	0.0	128.2	68.3	53.3%	128.2	Class Ⅰ
9	Kagoshima	0.0	40.6	28.0	69.0%	40.6	Class Ⅱ-A
10	Kumamoto	0.0	29.1	22.8	78.4%	29.1	Class Ⅱ-A
11	Hiroshima/Intl	0.8	22.4	19.6	87.5%	23.2	Class Ⅱ-A
12	Ishigaki	0.0	17.9	0.7	3.9%	17.9	Class Ⅲ
13	Kobe	0.0	16.0	2.7	16.9%	16.0	Class Ⅲ
14	Hakodate	0.0	15.9	15.3	96.2%	15.9	Class Ⅱ-A
15	Nagasaki	0.1	14.5	12.9	89.0%	14.6	Class Ⅱ-A
16	Sendai	0.9	12.6	—	—	13.5	Class Ⅱ-A
17	Komatsu	9.4	3.8	2.8	73.7%	13.2	Joint-use Aerodromes
18	Miyako Jima	0.0	12.4	1.0	8.1%	12.4	Class Ⅲ
19	Saga	1.5	10.5	8.7	82.9%	12.0	Class Ⅲ
20	Miyazaki	0.0	11.5	8.2	71.3%	11.5	Class Ⅱ-A
21	Oita	0.0	11.4	10.1	88.6%	11.4	Class Ⅱ-A
22	Takamatsu	0.0	10.7	9.1	85.0%	10.7	Class Ⅱ-A
Average					62.7%		

Source: Civil Aviation Bureau, Ministry of Land, Infrastructure, Transport and Tourism

3. ASSESSMENT OF NETWORK QUALITY

3.1 Concept of NetCost Model

In the NetCost model, which was first presented by Heemskerk and Veldhuis (2006a, 2006b) and developed by Veldhuis and Lieshout (2009), the concept of generalized travel costs is used. Generalized travel costs consist of three components: those related to travel time, frequency and airfares. These costs are an indication of the value of specific connections. The lower the costs of particular connections, the higher the perceived value for passengers. This value is determined in a specific algoritm, where costs are converted into utility levels and hence into an indication of consumer values. Route choice probabilities can be extracted from these values as well as transfer passenger market shares of airlines or airports in certain markets. Figure 6 shows the scheme of the NetCost model.

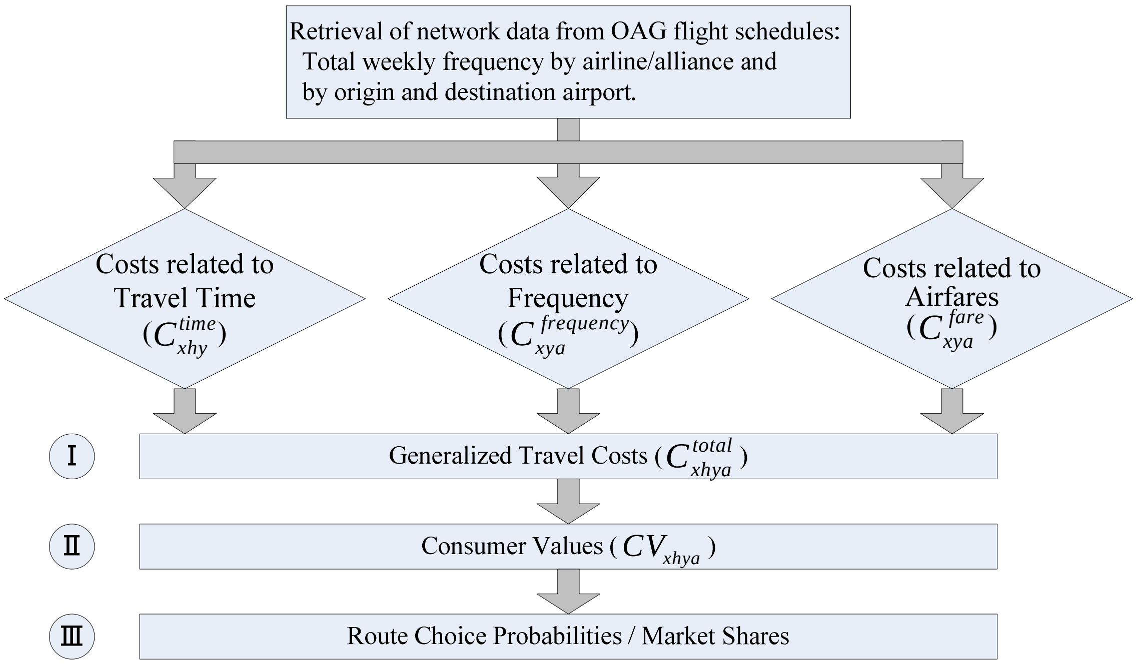

Figure 6. Scheme of NetCost Model

3.2 Generalized Travel Costs

(1) Costs related to Travel Time

The first cost component refers to the costs related to travel time. Direct connections have the shortest travel time, while a detour is involved with indirect connections. Detours lead to extra travel time, arising from longer flying time and connecting time at a hub, and consequently cause higher costs associated with travel time. Generalized travel costs related to travel time are determined by multiplying all travel time components with a monetary value of these components, which will be addressed below.

First, the great circle distance between each origin and destination is determined. This distance is measured by taking the geographical coordinates of the two ends and computing the distance in kilometers. By assuming a particular speed and allowing some time for take-off and landing, the flight time between two airports, x and y, is determined;

t_{xy}^{flight} flight time (in hours) between origin airport x and destination airport y. (1)

The travel time of direct connections is equal to the great circle distance (in hours). Travel time of indirect connections is, however, clearly longer than that of direct connections. In case of indirect connections, the great circle distances between an origin airport and an intermediate hub as well as between an intermediate hub and a destination airport are computed. Total flight time is determined by adding these two components together;

$$t_{xy}^{flight} = t_{xh}^{flight} + t_{hy}^{flight} \tag{2}$$

Where,

t_{xh}^{flight} flight time (in hours) between origin airport x and intermediate hub h.

t_{hy}^{flight} flight time (in hours) between intermediate hub h and destination airport y.

In case of indirect connections, the total travel time is longer than the non-stop flight time between x and y. The difference is the circuity time;

$$t_{xhy}^{circuity} = t_{xh}^{flight} + t_{hy}^{flight} - t_{xy}^{flight} \tag{3}$$

In addition, there is the connecting time at an intermediate hub, which is also added to the travel time;

$t_h^{connecting}$ connecting time (in hours) at intermediate hub h. (4)

Hence, the total elapsed travel time has now three components: non-stop flight time, circuity time and connecting time. Therefore, total travel time equals;

$$t_{xhy}^{total\ travel\ time} = t_{xy}^{flight} + t_{xhy}^{circuity} + t_h^{connecting} \quad (5)$$

The three components of total travel time do not, however, lead to the same degree of inconvenience. Circuity time and connecting time are perceived with a higher degree of inconvenience than in-flight time. Therefore, circuity time and connecting time are penalized with specific factors in the model. The model assumes a penalty factor depending on the flight distance, which is defined as;

$$\mu_{xy} = 3 - 0.075 * t_{xy}^{flight} \quad (6)$$

One single hour of circuity time of a short haul flight - say - one hour is penalized by a factor of close to 3, while one single hour of circuity time of a long haul flight - say - twelve hours is penalized by a factor of only little over 2. The difference between the penalty factors in short and long haul flights is justified by the recognition that one hour of circuity has relatively more inconvenience for short distances than for longer distances. The same argument holds for connecting time, although a penalty factor for connecting time is overall slightly higher, as connecting time is perceived as even more inconvenient than circuity time. With these assumptions, a perceived travel time is able to be determined, which has the above penalty factors incorporated;

$$t_{xhy}^{perceived\ \ travel\ \ time} = t_{xy}^{flight} + \alpha * \mu_{xy} * t_{xhy}^{circuity} + \beta * \mu_{xy} * t_{h}^{connecting} \quad (7)$$

$$(\alpha = 1,\ \beta = 1.25)$$

In case of direct connections, the perceived travel time equals the direct travel time, as there is no circuity nor connecting time. For indirect connections, the perceived travel time is longer than the actual travel time, as the assumed penalty factors have been incorporated.

Finally, the perceived travel time needs multiplying with the Value of Travel Time (VoTT) to obtain the generalized travel costs related to travel time.

$$c_{xhy}^{time} = VoTT * t_{xhy}^{perceived\ \ travel\ \ time} \quad (8)$$

(2) Costs related to Frequency

A flight hardly ever leaves exactly at the desired moment. The travel delay resulting from this is often called the schedule delay. The costs of this delay increase as frequencies decrease. The schedule delay is converted into costs by estimating the delay and multiplying it with the Value of Waiting Time (VoWT). This schedule delay in the model is approximated by taking the average time between two subsequent frequencies. This is an inverse function of the frequency level. Assuming the operational length of the day as 16 hours, the total operational length of the week equals 112 hours. The average schedule delay for a flight between airport x and airport y with airline (alliance) a is approximated by taking half of the average time between two subsequent frequencies f_{xya};

$$t_{xya}^{schedule\ delay} = \frac{0.5 * 112}{f_{xya}^{direct}} = \frac{56}{f_{xya}^{direct}} \tag{9}$$

Where,

f_{xya}^{direct} weekly direct frequency on the route between origin airport x and destination airport y with airline (alliance) a.

This equation represents the average schedule delay for direct connections. To determine the frequency level on indirect connections, a similar approach is adopted. For indirect connections, the schedule delays of the two flight components may be added up;

$$t_{xhya}^{schedule\ delay} = \frac{56}{f_{xha}^{direct}} + \frac{56}{f_{hya}^{direct}} \tag{10}$$

Where,

f_{xha}^{direct} weekly direct frequency on the route between origin airport x and intermediate hub h with airline (alliance) a.

f_{hya}^{direct} weekly direct frequency on the route between intermediate hub h and destination airport y with airline (alliance) a.

As the schedule delay is an inverse function of the frequency level, so is the frequency level an inverse function of the schedule delay. Therefore,

$$f_{xhya}^{indirect} = \frac{56}{t_{xhya}^{schedule\ delay}} \tag{11}$$

Where,

$f_{xhya}^{indirect}$ weekly indirect frequency on the route between origin airport x via intermediate hub h and destination airport y with airline (alliance) a.

When looking at the generalized travel costs related to frequency of a specific airline (alliance), direct as well as indirect frequencies have to be aggregated. For indirect connections, there may even be distinct routes via more hubs.

$$f_{xya}^{total} = f_{xya}^{direct} + \sum_{h} f_{xhya}^{indirect} \tag{12}$$

Therefore, the average schedule delay of an airline (alliance) will be;

$$t_{xya}^{schedule\ delay} = \frac{56}{f_{xya}^{total}} \tag{13}$$

This specification, however, leads to unrealistically high average schedule delay and consequently unrealistically high costs for routes with low weekly frequencies. If the frequency level is as low as only once per week, for example, the schedule delay results in 56 hours, using this specification. It can be assumed that passengers in reality do not perceive the full length of the schedule delay as being inconvenient, as this period may be used productively. Therefore, some adjustments are made for frequencies lower than 28 per week (4 daily). In the model, the schedule delay for frequencies lower than 28 per week is determined as;

$$t_{xya}^{schedule\ delay} = 3.96 - 0.07 * f_{xya}^{total} \quad \text{if} \quad f_{xya}^{total} < 28 \tag{14}$$

The effects of this change are visualized in Figure 7. Waiting time still increases for lower frequencies, but not exponentially. The maximum waiting time now approaches 4 hours only.

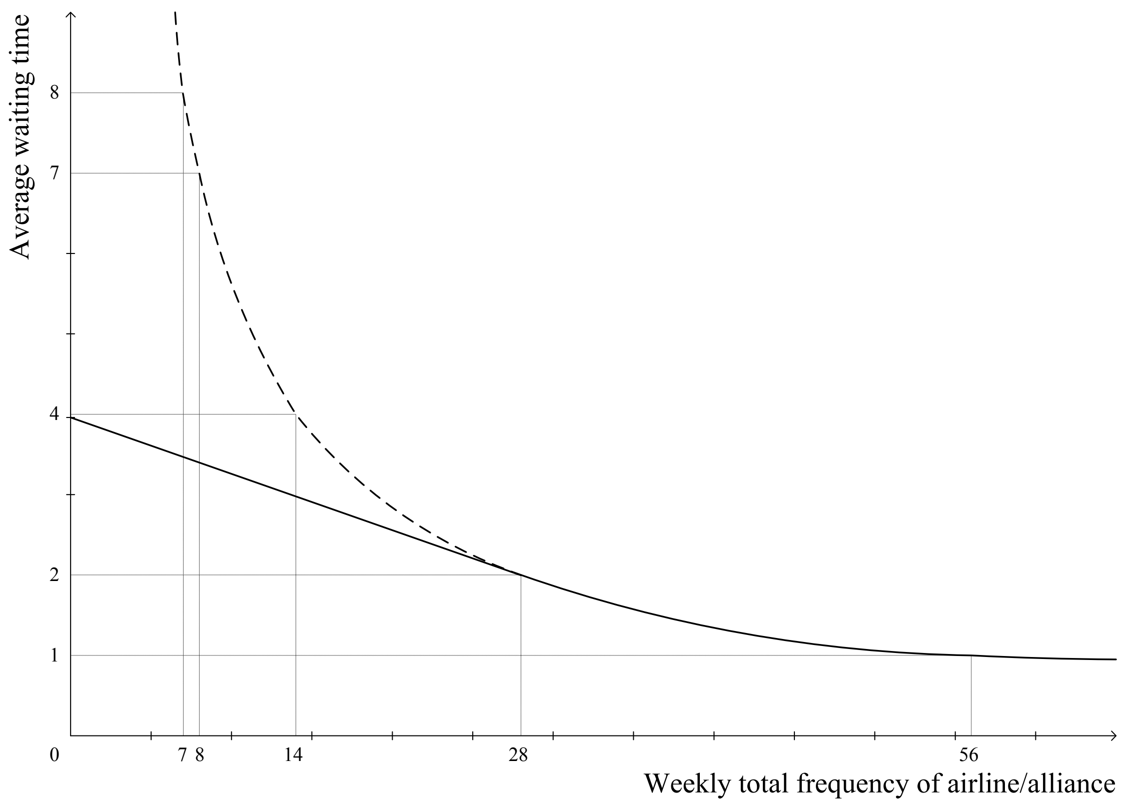

Figure 7. Average Schedule Delay as a Function of Frequency

(before and after adjustments)

The final process is the determination of the generalized travel costs. This requires multiplying the average schedule delay by the Value of Waiting Time (VoWT). This is done for each direct and indirect connection. The determination of the generalized travel costs related to frequency is now;

$$c_{xya}^{frequency} = VoWT * t_{xya}^{schedule\ delay} \quad (15)$$

(3) Costs related to Airfares

The final component of generalized travel costs is the airfares. Consistent statistical information on airfares is very limited available, which consequently cannot be used in the model. There are, however, some systematic factors that determine the level of airfares to some extent, so these factors are used in the model to determine the expected airfares.

One of these systematic factors is clearly the distance between the origin and the final destination, irrespective of the route flown. The airfares are therefore based on the great circle distance (in hours) between the origin and the final destination. From this distance, the 'reference fare' is computed. But the airfares are not determined only by the distance. Other systematic factors lead to possible adjustments of the reference fare. In the model, the expected airfares depend also on the;

1) Route types: direct or indirect

2) Carrier types: network or point-to-point carrier

3) Airlines or alliances

4) Passenger travel purposes: business or leisure

5) Competition levels

1) Route types: direct or indirect (adjustment factor: π_r)

Generally, the airfares on direct routes are higher than those on indirect routes, even though the distance flown of indirect routes is longer. The rationale behind this is that the perceived quality and therefore the willingness-to-pay of indirect flights are lower. In this model, the route adjustment factor (π_r) is introduced to reflect this difference between them.

2) Carrier types: network or point-to-point carrier (adjustment factor: π_o)

The second adjustment factor depends on the carrier type (π_o). Fares also depend on the type of carrier operating a certain route. The NetCost model distinguishes two types of carriers: network carriers and point-to-point carriers. Network carriers are generally the established flag carriers, who develop networks around their central hubs. Point-to-point carriers do not develop networks at their home bases, but offer frequent direct services. The latter category includes charter services or so-called low-cost carriers.

3) Airlines or alliances (adjustment factor: π_a)

Airfare differences between airlines or alliances within these two main carrier types can be reflected, if necessary, by introducing an additional adjustment factor for particular airlines or alliances (π_a).

4) Passenger travel purposes: business or leisure (adjustment factor: π_p)

The model also has an option for assuming an adjustment factor for passenger travel purposes (π_p). Higher airfares are commonly paid by business passengers than by leisure passengers for some benefits.

5) Competition levels (adjustment factor: π_c)

The final adjustment made on the reference fare is based on the competition levels in the market. Generally, airfares in the market with high competition levels are significantly lower than those in the market with low competition levels. The competition level in each specific market is approached by determining the concentration index in the market. Markets with a high concentration index, where most of the services are provided by a limited number of carriers, have limited competition, while markets with a low concentration index, where many competing carriers provide the services, have strong competition.

The concentration index is obtained by taking the connectivity shares of each of the competitors in a specific market. For each connection in a particular market, the weekly connectivity level is determined. For direct non-stop connections, weekly connectivity equals weekly frequency. For direct multi-stop and indirect connections, weekly connectivity level is lower than weekly frequency level, as the elapsed time is longer. Hence, the frequency level is adjusted by applying a quality index (ranging from 0 to 1, depending on the elapsed time). For details on how this quality index is calculated, see Veldhuis (1997), Burghouwt and Veldhuis (2006), Burghouwt et al. (2009) and De Wit et al. (2009).

The total connectivity from origin airport x to destination airport y with airline (alliance) a is now determined as;

$$CNU_{xya} = f_{xya}^{direct} + \sum_{h} (f_{xhya}^{indirect} * q_{xhya}) \qquad (16)$$

Where,

CNU_{xya} weekly connectivity units on the route between origin airport x and destination airport y with airline (alliance) a.

f_{xya}^{direct} weekly direct frequency on the route between origin airport x and destination airport y with airline (alliance) a.

$f_{xhya}^{indirect}$ weekly indirect frequency on the route between origin airport x via intermediate hub h and destination airport y with airline (alliance) a.

q_{xhya} quality index ranging from 0 to 1.

These connectivity levels with airlines (alliances) are used to determine the concentration index in the market between x and y. Aggregating the squares of the connectivity shares of each of the competing airlines (alliances) results in the Hirschman-Herfindahl Index (HHI) of the market between x and y;

$$HHI_{xy} = \sum_a \left(\frac{CNU_{xya}}{\sum_a CNU_{xya}}\right)^2 \quad (17)$$

The final issue is to determine the adjustment to the reference fare based on this competition level. This adjustment factor (π_c) is supposed, in the model, to be a function of competition level;

$$\pi_c = \eta + \varphi * HHI_{xy} \quad (18)$$

Finally, the expected airfares are expressed with all adjustment factors;

$$c_{xya}^{fare} = (reference\ \ fare) * \pi_r * \pi_o * \pi_a * \pi_p * \pi_c \quad (19)$$

In summary, the total generalized travel costs can now be determined by adding up these three components ((8), (15) and (19));

$$c_{xhya}^{total} = c_{xhy}^{time} + c_{xya}^{frequency} + c_{xya}^{fare} \quad (20)$$

3.3 Consumer Values and Route Choice Probabilities

The generalized travel costs are a main determinant of the attractiveness of a particular route.

This, in turn, determines the probability that this route alternative is chosen. It is, however, not only the cost level of the route, but also the frequency level at which the route is offered. Therefore, utility functions are used to derive an indicator, expressing the attractiveness for passengers: consumer values. From these consumer values, route choice probabilities are derived.

The utility is a function of generalized travel costs;

$$U_{xhya} = e^{\rho * c_{xhya}^{total}} \tag{21}$$

Where,

U_{xhya} utility of the connection between origin airport x via intermediate hub h and destination airport y with airline (alliance) a. In case of direct connections, h=0.

ρ "spread" parameter.

This function expresses the value for passengers of one particular connection. If compared with other connections, the value of this particular connection is firstly multiplied by the frequency of airline (alliance) a in the market between x and y, from which the total consumer values of the connection are obtained between origin airport x via intermediate hub h and destination airport y with airline (alliance) a;

$$CV_{xhya} = f_{xhya} * U_{xhya} \tag{22}$$

Where,

CV_{xhya} consumer values of the connection between origin airport x via intermediate hub h and destination airport y with airline (alliance) a. In case of direct connections, h=0.

This consumer values can now be used in assessing the attractiveness of a particular route vis-à-vis other routes;

$$p_{xhya} = \frac{CV_{xhya}}{\sum_h \sum_a CV_{xhya}} = \frac{CV_{xhya}}{CV_{xy}} \tag{23}$$

Where,

p_{xhya} probabilities the connection (via intermediate hub h) with airline (alliance) a is chosen in the market between x and y. In case of direct connections, h=0.

CV_{xy} total consumer values in the market between x and y.

4. ROUTE CHOICE PROBABILITIES OF PASSENGERS DEPARTING FROM JAPAN BEFORE AND AFTER OPENING OF SCHEDULED INTERNATIONAL SERVICES AT TOKYO INTERNATIONAL AIRPORT

4.1 Assumptions on Parameters

The previous section has addressed the methodology behind the determination of the generalized travel costs, the consumer values and the route choice probabilities within the NetCost model. This section shows an application of this model; how the model may be used in estimating the route choice probabilities and the transfer passenger market shares at major hub airports with regard to passengers departing from Japan.

Basically in line with the literatures applied in Europe (Spiller (1989), Reiss and Spiller (1989), Lijesen (2004)), or the experiences in the European context, the assumptions on parameters are as follows.

In the model, the value of travel time (VoTT) of 20 euro per hour is assumed for passengers with leisure travel purpose, and 50 euro per hour for passengers with business travel purpose. In case no distinction is made between these two travel purposes, the value of travel time equals 35 euro. The value of waiting time (VoWT) is assumed only 40% of the value of travel time. Background of this is that the time involved with the schedule delay can be used more productively than the actual travel time. Hence, the value of waiting time equals 8 euro for leisure passengers and 20 euro for business passengers. In case no distinction is made between these two travel purposes, the value of waiting time equals 14 euro.

As for the reference fare, it is assumed to start with 80 euro, and for each additional hour of flight time, 40 euro is added.

With regard to the adjustment factor on route types (π_r), the assumption is made that the airfares on direct routes are 5% higher than the reference fare and those on indirect routes are 5% lower than the reference fare. This means that this factor has a value of 1.05 for direct flights and 0.95 for indirect flights. Regarding the adjustment factor on carrier types (π_o), it is assumed in the model that the airfares of point-to-point carriers are, on average, 30% lower than those of network carriers. Concerning the adjustment factor on passenger travel purposes (π_p), it is assumed that business passengers pay airfares 25 % above the reference fare, while leisure passengers pay airfares 25 % below the reference fare. Finally, as for the adjustment factor on competition levels (π_c), the assumption is made that for leisure passengers, the airfares are

25 % lower in case of maximum competition (η =-0.25, HHI_{xy}=0), and 25 % higher in case of monopoly (η =-0.25, ϕ =0.5, HHI_{xy}=1). For business passengers, it is assumed that the airfares are 10 % lower in case of maximum competition (η =-0.10, HHI_{xy}=0), and 10 % higher in case of monopoly (η =-0.10, ϕ =0.2, HHI_{xy}=1).

Table 7 summarizes the assumptions on parameters in the model.

Table 7. Assumptions on Parameters to calculate Generalized Travel Costs

	Leisure Passengers	Business Passengers	No Distinction
(1) Costs related to travel time Value of travel time per hour (VoTT)	€ 20	€ 50	€ 35
(2) Costs related to frequency Value of waiting time per hour (VoWT	€ 8	€ 20	€ 14
(3) Costs related to airfares Reference fare	€80 + €40 * flight time		
1) Route types (π_r)	5% higher than reference fare on direct routes (π_r=1.05) 5% lower than reference fare on indirect routes (π_r=0.95)		
2) Carrier types (π_o)	Airfares of point-to-point carriers are 30% lower than those of network carriers		
3) Airlines or alliances (π_a)	An additional adjustment factor for particular airlines or alliances, if necessary		
4) Passenger travel purposes (π_p)	25 % below reference fare (π_p=0.75)	25 % above reference fare (π_p=1.25)	
5) Competition levels (π_c)	25 % lower in case of maximum competition (π_c=0.75)	10 % lower in case of maximum competition (π_c=0.90)	
	25 % higher in case of monopoly (π_c=1.25)	10 % higher in case of monopoly (π_c=1.10)	

As for the new international services at Haneda, the government is now under negotiations with counterparts and every route hasn't been fixed yet. In this paper, the analyses are based on the assumptions with the up-to-date information provided by Civil Aviation Bureau, Ministry of

Land, Infrastructure, Transport and Tourism, Japan, shown in Table 8. Although the Japanese government reached the agreements with the German and the Dutch governments, as mentioned in 2.1, Lufthansa and KLM Royal Dutch Airlines haven't announced yet to start their flight schedules to Frankfurt and Amsterdam, respectively.

Table 8. Assumptions on Scheduled International Services at Haneda, as of October 2010

Region	Airport Counrty	No.of Flights per week	Airlines
Asia & Oceania	Seoul/Gimpo, Rep. of Korea	70	Japan Airlines (21), All Nippon Airways (21), Korean Air (14), Asiana Airlines (14)
	Beijing/Capital, China	28	Japan Airlines (7), All Nippon Airways (7), Air China (14)
	Shanghai/Hongqiao, China	28	Japan Airlines (7), All Nippon Airways (7), China Eastern Airlines (7), Shanghai Airlines (7)
	Hong Kong, China	35	Japan Airlines (7), All Nippon Airways (7), Cathay Pacific Airways (14), Hong Kong Airlines (7)*
	Taipei/Songshan, Chinese Taipei	56	Japan Airlines (14), All Nippon Airways (14), China Airlines (14)*, Eva Airways (14)
	Bangkok/Intl, Thailand	21	JALways (7), All Nippon Airways (7), Thai Airways International (7)
	Kuala Lumpur/Intl, Malaysia	7	AirAsia X (7)*
	Kota Kinabalu, Malaysia	3	Malaysia Airlines System (3)
	Singapore/Changi	28	Japan Airlines (7), All Nippon Airways (7), Singapore Airlines (14)
	Honolulu USA	21	JALways (7), All Nippon Airways (7), Hawaiian Airlines (7)*
Europe	London/Heathrow, UK	7	British Airways (7)*
	Paris/Charles De Gaulle, France	7	Japan Airlines (7)
North America	New York/John F. Kennedy, USA	7	American Airlines (7)
	Los Angeles/Intl, USA	14	All Nippon Airways (7), Delta Air Lines (7)
	San Francisco/Intl, USA	7	Japan Airlines (7)
	Detroit/Metropolitan	7	Delta Air Lines (7)
	Vancouver, Canada	7	Air Canada (7)*

Notes: * means they announced to start services, but haven not included in OAG flight schedules yet.

The same numbers are assumed on arrival.

4.2 Data used and Classification of Study Area

The airline network data (origin, destination, published carrier and number of operations) are retrieved from OAG flight schedules in the third week of September, 2010 and in the third week of March, 2011. In this study, only online connections are considered as viable connections. In other words, transfers have to take place between flights of the same airline or the same global airline alliance. For the years analyzed, three global airline alliances are distinguished: Oneworld, SkyTeam and Star Alliance (see Appendix A).

The study area consists of eight market segments between Japan and the rest of the world; between Japan and Asia & Oceania (excluding Japan), between Japan and Europe, between Japan and North America, between Japan and Latin America, between Japan and Middle East, between Japan and Africa, between Japan and Japan (domestic) and between Japan and World. Note that airports in Honolulu, Kona, Guam, Saipan and Palau are included in Asia & Oceania, not in North America in this paper. The analysis considers the connectivity between all Japanese airports and airports worldwide or between all Japanese airports.

4.3 Results

4.3.1 Market Shares of Direct and Indirect Connections

Table 9 shows the market shares of direct and indirect connections in each market segment in March 2011. In the short-haul markets, such as between Japan and Japan and between Japan and

Asia & Oceania, direct connections account for over 99 % and 97 % for both travel purposes, respectively. In reality, there are often direct connections available. These direct connections are of a higher quality because of lacking connecting and circuity time, which enables these connections to obtain very high market shares over short distances. In these markets, connecting and circuity time of indirect connections are relatively large compared with direct connections with high frequencies. For this reason, direct connections have a total market share of almost 100 % in these markets, where many direct flights are available.

Meanwhile, in the long-haul market to Latin America, direct connections have much smaller shares, slightly less than 14 % for both travel purposes. As for the markets between Japan and Europe and between Japan and Africa, approximately half of the business and leisure travelers choose an indirect connection. Around 30 % of all connections for both travel purposes are indirect ones as for the markets between Japan and North America and between Japan and Middle East. Taking into account all markets (Japan-World), almost all connections are made directly, largely because the domestic markets are much larger compared with international ones, which is quite reflected in the market shares in this segment.

Table 9. Market Shares of Direct and Indirect Connections in each Market Segment, March 2011

Market Segment	Direct Connections		Indirect Connections		Total	
	Leisure Passengers	Business Passengers	Leisure Passengers	Business Passengers	Leisure Passengers	Business Passengers
(1) Japan - Asia&Oceania (exc.Japan)	97.84%	97.15%	2.16%	2.85%	100%	100%
(2) Japan - Europe	46.64%	50.26%	53.36%	49.74%	100%	100%
(3) Japan - North America	64.58%	62.43%	35.42%	37.57%	100%	100%
(4) Japan - Latin America	13.55%	13.70%	86.45%	86.30%	100%	100%
(5) Japan - Middle East	71.91%	68.79%	28.09%	31.21%	100%	100%
(6) Japan - Africa	53.88%	59.04%	46.12%	40.96%	100%	100%
(7) Japan - Japan	99.50%	99.37%	0.50%	0.63%	100%	100%
(8.1) Japan - World	99.43%	99.26%	0.57%	0.74%	100%	100%
(8.1) Japan - World (exc.Japan)	97.84%	97.13%	2.16%	2.87%	100%	100%

4.3.2 Market Shares of Hubs on Indirect Connections

The market shares of relevant hubs on indirect connections in each market segment are shown in Table 10, before and after the opening of scheduled international services at Haneda. The first observation both in September 2010 and in March 2011 is that almost the same trends can be seen in the markets between Japan and Japan and between Japan and World, owing to the huge domestic markets. The largest hub is Tokyo/Haneda, followed by Osaka/Itami, Nagoya/Chubu, Sapporo/Chitose, Fukuoka, Naha (Okinawa) and Osaka/Kansai. Among these domestic hubs are Seoul/Incheon and Shanghai/Pudong for the market between Japan and World.

The same trends can be also observed in the markets between Japan and Asia & Oceania and between Japan and World (excluding Japan). Seoul/Incheon and Shanghai/Pudong account for more than 50 % together for both travel purposes in both cases. Tokyo/Haneda is ranked tenth in

September 2010 with around 3 % market shares for both travel purposes, meanwhile ranked sixth in March 2011 with around 5 % market shares for both travel purposes. Other major Asian hubs, such as Pusan, Beijing/Capital, Dalian and Taipei/Taoyuan are ranked among other major Japanese hubs, Tokyo/Narita, Osaka/Kansai, Nagoya/Chubu and Fukuoka, occupying a market share of around 5 % for both travel purposes in both cases.

As for the market shares on indirect connections between Japan and Europe, the European hubs, such as Frankfurt (around 15 % for both travel purposes in both cases), Helsinki (more than 12 % for both travel purposes in September 2010 and more than 10 % for both travel purposes in March 2011), Munich (more than 8 % for both travel purposes in both cases), Paris/Charles de Gaulle (more than 8 % for both travel purposes in September 2010 and more than 7 % for both travel purposes in March 2011) and Amsterdam (more than 7 % for both travel purposes in September 2010 and more than 8 % for both travel purposes in March 2011) are the most popular intermediate hubs. The striking finding is Seoul/Incheon is ranked third in both cases, occupying around 10 % market shares for both travel purposes in both cases. Tokyo/Haneda is predicted to get a market share of 2.2 % for leisure passengers and that of 2.4 % for business passengers in March 2011, owing to the opening of scheduled international services to London/Heathrow and Paris/Charles de Gaulle.

As for the market shares on indirect connections between Japan and North America, the main hubs in the United States are Chicago/O'Hare (16-19 % in September 2010 and 14-18 % in March 2011), San Francisco (11-14 % in September 2010 and 8-12 % in March 2011) and Los Angeles (7-9 % in both cases). Among the Asian hubs, Tokyo/Narita is ranked third in September 2010 (around 10 % market shares for both travel purposes) and ranked second in March 2011 (8-9 % market shares for both travel purposes). Seoul/Incheon is ranked seventh and eighth in September 2010 and in March 2011, respectively (around 5 % market shares for both travel purposes in both cases). Tokyo/Haneda is ranked third in March 2011 with approximately 9 % market shares for leisure passengers and 11 % market shares for business passengers, owing to the opening of scheduled international services to New York, Los Angeles, San Francisco, Detroit and Vancouver.

The US hubs, such as Dallas-Fort Worth, Houston and Los Angeles, and Mexico City are dominant in the market between Japan and Latin America, which together occupy a market share of around 80 % of all indirect connections for both travel purposes in September 2010 and around 70 % of all indirect connections for both travel purposes in March 2011.

Four hubs in Middle East, Dubai (15-18 % market shares in both cases), Doha (10-13 % market shares in both cases), Abu Dhabi (5-7 % market shares in both cases) and Istanbul (around 6 % market shares for leisure passengers and around 15 % for business passengers in both cases), and three hubs in Asia, Seoul/Incheon (18-23 % market shares in September 2010 and 15-18 % market shares in March 2011), Beijing/Capital (7-10 % market shares in both cases) and Hong Kong (5-9 % market shares in both cases) are top six hubs in the market between Japan and Middle East.

In the market between Japan and Africa, three hubs in Europe, Rome/Fiumicino (9-13 % market shares in both cases), Paris/Charles de Gaulle (around 10 % market shares in September 2010 and 9 % market shares in March 2011) and Frankfurt (9-10 % market shares in September 2010 and 8-9 % market shares in March 2011) for a historical reason, and three hubs in Middle East, Istanbul (11-13 % market shares in both cases), Dubai (7-9 % market shares in both cases) and Doha (6-8 % market shares in both cases) for a geographical reason connect this market well, on top of African main gateway, Cairo (15-19 % market shares in September 2010 and 17-22 % market shares in March 2011).

The last observation is that Seoul/Incheon is a dominant hub in all markets except between

Japan and Latin America and between Japan and Africa. It is ranked first in the markets regarding Asia & Oceania and World (excluding Japan), ranked second in the market regarding Middle East, ranked third in the market regarding Europe, ranked fourth in the market regarding World and ranked eighth in the markets regarding North America in March 2011, largely because of the strategic well-developed hub-and-spoke networks by Korean air carriers to Japan.

Table 10. Market Shares on Indirect Connections in each Market Segment, before and after Opening of Scheduled International Services at Haneda

(1) Japan - Asia&Oceania (excluding Japan)

Before (September, 2010)				After (March, 2011)			
Rank	Airport	Leisure	Business	Rank	Airport	Leisure	Business
1	**Seoul/Incheon**	**31.92%**	**30.44%**	**1**	**Seoul/Incheon**	**32.78%**	**31.45%**
2	Shanghai/Pudong	21.61%	21.78%	2	Shanghai/Pudong	18.92%	18.98%
3	**Osaka/Kansai**	**5.38%**	**4.94%**	**3**	**Osaka/Kansai**	**5.69%**	**5.03%**
4	Beijing/Capital	5.35%	7.06%	4	Pusan	5.55%	4.47%
5	Pusan	5.28%	4.27%	5	Fukuoka	5.33%	4.96%
6	Fukuoka	5.19%	4.87%	**6**	**Tokyo/Haneda**	**4.97%**	**5.97%**
7	Dalian	4.44%	4.04%	7	Beijing/Capital	4.74%	6.14%
8	Taipei/Taoyuan	3.91%	3.77%	8	Taipei/Taoyuan	4.48%	4.36%
9	**Nagoya/Chubu**	**3.68%**	**3.38%**	9	Dalian	4.10%	3.74%
10	**Tokyo/Haneda**	**2.98%**	**3.71%**	**10**	**Nagoya/Chubu**	**3.42%**	**3.06%**
	Others	10.26%	11.76%		Others	10.01%	11.85%
(11)	Tokyo/Narita	2.27%	2.43%	(11)	Tokyo/Narita	2.51%	2.67%
Total		100%	100%	Total		100%	100%

(2) Japan - Europe

Before (September, 2010)				After (March, 2011)			
Rank	Airport	Leisure	Business	Rank	Airport	Leisure	Business
1	Frankfurt	14.34%	15.01%	1	Frankfurt	14.35%	15.23%
2	Helsinki	12.52%	12.97%	2	Helsinki	10.40%	10.78%
3	**Seoul/Incheon**	**10.39%**	**9.54%**	**3**	**Seoul/Incheon**	**9.87%**	**8.71%**
4	Munich	8.13%	8.64%	4	Amsterdam	8.91%	8.63%
5	Paris/Charles de Gaulle	8.10%	8.29%	5	Munich	8.20%	8.63%
6	Amsterdam	7.33%	7.15%	6	Paris/Charles de Gaulle	7.42%	7.74%
7	London/Heathrow	5.17%	4.46%	7	London/Heathrow	5.72%	5.58%
8	Copenhagen	4.61%	4.30%	8	Beijing/Capital	4.47%	3.48%
9	Beijing/Capital	4.24%	3.37%	9	Copenhagen	4.23%	3.87%
10	**Tokyo/Narita**	**4.12%**	**4.70%**	**10**	**Tokyo/Narita**	**3.70%**	**4.28%**
	Others	21.05%	21.58%		Others	22.74%	23.08%
(17)	Nagoya/Chubu	0.78%	0.98%	(17)	Tokyo/Haneda	2.19%	2.37%
(18)	Osaka/Kansai	0.46%	0.75%	(18)	Nagoya/Chubu	0.72%	0.80%
—	Tokyo/Haneda	0.00%	0.00%	(19)	Osaka/Kansai	0.41%	0.55%
Total		100%	100%	Total		100%	100%

(3) Japan - North America

Before (September, 2010)				After (March, 2011)			
Rank	Airport	Leisure	Business	Rank	Airport	Leisure	Business
1	Chicago/O'Hare	19.76%	16.53%	1	Chicago/O'Hare	18.87%	14.30%
2	San Francisco	11.72%	14.77%	**2**	**Tokyo/Narita**	**9.78%**	**8.42%**
3	**Tokyo/Narita**	**11.41%**	**10.71%**	**3**	**Tokyo/Haneda**	**8.98%**	**10.88%**
4	Los Angeles	8.79%	9.35%	4	San Francisco	8.92%	12.06%
5	Dallas-Fort Worth	6.53%	6.20%	5	Los Angeles	7.79%	9.73%
6	Minneapolis-Saint Paul	5.94%	5.39%	6	Detroit	6.21%	7.80%
7	**Seoul/Incheon**	**5.86%**	**5.68%**	7	Dallas-Fort Worth	6.16%	5.36%
8	Detroit	5.78%	6.56%	**8**	**Seoul/Incheon**	**5.69%**	**5.06%**
9	Washington/Dulles	3.91%	3.86%	9	Minneapolis-Saint Paul	5.61%	4.62%
10	Vancouver	3.71%	4.68%	10	Vancouver	4.92%	7.00%
	Others	16.59%	16.26%		Others	17.07%	14.78%
(19)	Osaka/Kansai	0.34%	0.41%	(18)	Osaka/Kansai	0.54%	0.38%
(—)	Nagoya/Chubu	0.00%	0.00%	(—)	Nagoya/Chubu	0.00%	0.00%
(—)	Tokyo/Haneda	0.00%	0.00%				
Total		100%	100%	Total		100%	100%

(4) Japan - Latin America

Before (September, 2010)				After (March, 2011)			
Rank	Airport	Leisure	Business	Rank	Airport	Leisure	Business
1	Dallas-Fort Worth	27.86%	23.46%	1	Dallas-Fort Worth	24.20%	20.07%
2	Houston	23.11%	24.49%	2	Houston	22.07%	22.71%
3	Los Angeles	17.43%	15.34%	3	Los Angeles	13.57%	12.77%
4	Mexico City	13.27%	16.15%	4	Mexico City	11.63%	13.11%
5	Atlanta	6.06%	7.14%	5	Atlanta	6.70%	7.74%
6	Chicago/O'Hare	4.06%	3.48%	6	Chicago/O'Hare	5.54%	4.67%
7	San Francisco	2.07%	1.88%	7	San Francisco	4.99%	4.72%
8	Toronto/Pearson	1.87%	2.84%	8	Minneapolis-Saint Paul	2.44%	2.09%
9	Newark	1.45%	2.15%	9	Newark	2.32%	3.32%
10	Salt Lake City	1.26%	1.06%	10	Toronto/Pearson	2.31%	3.38%
	Others	1.58%	2.00%		Others	4.23%	5.41%
(—)	Tokyo/Narita	0.00%	0.00%	(—)	Tokyo/Narita	0.00%	0.00%
(—)	Osaka/Kansai	0.00%	0.00%	(—)	Osaka/Kansai	0.00%	0.00%
(—)	Nagoya/Chubu	0.00%	0.00%	(—)	Nagoya/Chubu	0.00%	0.00%
(—)	Tokyo/Haneda	0.00%	0.00%	(—)	Tokyo/Haneda	0.00%	0.00%
Total		100%	100%	Total		100%	100%

(5) Japan - Middle East

Before (September, 2010)				After (March, 2011)			
Rank	Airport	Leisure	Business	Rank	Airport	Leisure	Business
1	**Seoul/Incheon**	**18.96%**	**23.15%**	1	Dubai	18.40%	15.56%
2	Dubai	18.86%	16.12%	**2**	**Seoul/Incheon**	**16.73%**	**21.87%**
3	Doha	13.06%	10.41%	3	Doha	13.75%	10.83%
4	Beijing/Capital	10.14%	7.08%	4	Beijing/Capital	10.81%	7.58%
5	Hong Kong	8.90%	5.57%	5	Hong Kong	9.26%	5.89%
6	Abu Dhabi	6.84%	5.49%	6	Abu Dhabi	7.04%	5.64%
7	Istanbul	6.26%	15.04%	7	Istanbul	6.24%	15.03%
8	Cairo	2.92%	2.51%	8	Cairo	3.52%	3.02%
9	Guangzhou	2.50%	1.47%	9	Guangzhou	2.92%	1.71%
10	New Delhi	2.16%	1.46%	10	New Delhi	2.23%	1.50%
	Others	9.39%	11.70%		Others	9.09%	11.37%
(13)	Tokyo/Narita	1.13%	2.21%	(13)	Tokyo/Narita	1.04%	2.22%
(16)	Osaka/Kansai	0.62%	1.31%	(16)	Osaka/Kansai	0.51%	1.08%
(—)	Nagoya/Chubu	0.00%	0.00%	(—)	Nagoya/Chubu	0.00%	0.00%
(—)	Tokyo/Haneda	0.00%	0.00%	(—)	Tokyo/Haneda	0.00%	0.00%
Total		100%	100%	Total		100%	100%

(6) Japan - Africa

Before (September, 2010)				After (March, 2011)			
Rank	Airport	Leisure	Business	Rank	Airport	Leisure	Business
1	Cairo	15.15%	19.99%	1	Cairo	17.18%	22.13%
2	Istanbul	13.76%	11.42%	2	Istanbul	13.42%	11.01%
3	Rome/Fiumicino	12.67%	9.65%	3	Rome/Fiumicino	13.18%	9.69%
4	Paris/Charles de Gaulle	10.42%	10.15%	4	Dubai	9.71%	7.66%
5	Frankfurt	10.33%	9.13%	5	Paris/Charles de Gaulle	9.70%	9.18%
6	Dubai	9.82%	7.87%	6	Frankfurt	9.62%	8.28%
7	Doha	8.78%	6.09%	7	Doha	8.43%	5.83%
8	Beijing/Capital	4.56%	4.81%	8	Beijing/Capital	4.02%	4.61%
9	**Tokyo/Narita**	**2.26%**	**6.88%**	**9**	**Tokyo/Narita**	**2.56%**	**7.49%**
10	London/Heathrow	1.76%	1.31%	10	London/Heathrow	1.88%	1.74%
	Others	10.49%	12.70%		Others	10.30%	12.37%
(12)	Osaka/Kansai	1.52%	4.69%	(12)	Osaka/Kansai	1.47%	4.36%
(—)	Nagoya/Chubu	0.00%	0.00%	(—)	Nagoya/Chubu	0.00%	0.00%
(—)	Tokyo/Haneda	0.00%	0.00%	(—)	Tokyo/Haneda	0.00%	0.00%
	Total	100%	100%		Total	100%	100%

(7) Japan - Japan

Before (September, 2010)				After (March, 2011)			
Rank	Airport	Leisure	Business	Rank	Airport	Leisure	Business
1	**Tokyo/Haneda**	**43.54%**	**44.57%**	**1**	**Tokyo/Haneda**	**42.42%**	**44.28%**
2	Osaka/Itami	20.03%	19.29%	2	Osaka/Itami	27.28%	25.22%
3	**Nagoya/Chubu**	**9.61%**	**9.62%**	**3**	**Nagoya/Chubu**	**9.19%**	**8.73%**
4	Sapporo/Chitose	7.17%	7.50%	4	Sapporo/Chitose	5.48%	6.13%
5	Fukuoka	7.04%	7.03%	5	Fukuoka	4.68%	4.85%
6	Naha (Okinawa)	3.37%	4.29%	6	Naha (Okinawa)	3.14%	4.13%
7	**Osaka/Kansai**	**3.34%**	**2.78%**	7	Sendai	2.59%	2.22%
8	Sendai	2.13%	1.76%	**8**	**Osaka/Kansai**	**1.84%**	**1.57%**
9	Kagoshima	1.09%	0.94%	9	Kagoshima	0.95%	0.81%
10	Komatsu (Kanazawa)	0.92%	0.69%	10	Komatsu (Kanazawa)	0.91%	0.70%
	Others	1.76%	1.51%		Others	1.52%	1.37%
(12)	Tokyo/Narita	0.56%	0.51%	(12)	Tokyo/Narita	0.54%	0.51%
	Total	100%	100%		Total	100%	100%

(8.1) Japan - World

Before (September, 2010)				After (March, 2011)			
Rank	Airport	Leisure	Business	Rank	Airport	Leisure	Business
1	**Tokyo/Haneda**	**35.96%**	**35.96%**	**1**	**Tokyo/Haneda**	**36.31%**	**37.00%**
2	Osaka/Itami	16.29%	15.23%	2	Osaka/Itami	22.83%	20.43%
3	**Nagoya/Chubu**	**8.50%**	**8.30%**	**3**	**Nagoya/Chubu**	**8.24%**	**7.65%**
4	Fukuoka	6.69%	6.57%	**4**	**Seoul/Incheon**	**5.33%**	**5.93%**
5	**Seoul/Incheon**	**5.95%**	**6.38%**	5	Fukuoka	4.79%	4.86%
6	Sapporo/Chitose	5.87%	5.98%	6	Sapporo/Chitose	4.62%	5.03%
7	Shanghai/Pudong	4.03%	4.56%	7	Shanghai/Pudong	3.08%	3.58%
8	**Osaka/Kansai**	**3.72%**	**3.23%**	8	Naha (Okinawa)	2.64%	3.36%
9	Naha (Okinawa)	2.75%	3.41%	**9**	**Osaka/Kansai**	**2.47%**	**2.22%**
10	Sendai	1.77%	1.43%	10	Sendai	2.21%	1.84%
	Others	8.48%	8.96%		Others	7.48%	8.10%
(14)	Tokyo/Narita	0.88%	0.92%	(12)	Tokyo/Narita	0.86%	0.92%
Total		100%	100%	Total		100%	100%

(8.2) Japan - World (excluding Japan)

Before (September, 2010)				After (March, 2011)			
Rank	Airport	Leisure	Business	Rank	Airport	Leisure	Business
1	**Seoul/Incheon**	**31.88%**	**30.30%**	**1**	**Seoul/Incheon**	**32.74%**	**31.27%**
2	Shanghai/Pudong	21.58%	21.66%	2	Shanghai/Pudong	18.89%	18.84%
3	**Osaka/Kansai**	**5.37%**	**4.91%**	**3**	**Osaka/Kansai**	**5.68%**	**4.99%**
4	Beijing/Capital	5.35%	7.03%	4	Pusan	5.54%	4.44%
5	Pusan	5.27%	4.24%	5	Fukuoka	5.32%	4.92%
6	Fukuoka	5.18%	4.84%	**6**	**Tokyo/Haneda**	**4.97%**	**5.97%**
7	Dalian	4.43%	4.01%	7	Beijing/Capital	4.74%	6.11%
8	Taipei/Taoyuan	3.91%	3.74%	8	Taipei/Taoyuan	4.48%	4.33%
9	**Nagoya/Chubu**	**3.68%**	**3.36%**	9	Dalian	4.10%	3.71%
10	**Tokyo/Haneda**	**2.98%**	**3.68%**	**10**	**Nagoya/Chubu**	**3.41%**	**3.04%**
	Others	10.38%	12.22%		Others	10.13%	12.37%
(11)	Tokyo/Narita	2.28%	2.45%	(11)	Tokyo/Narita	2.51%	2.70%
Total		100%	100%	Total		100%	100%

5. SUMMARY AND CONCLUSION

The application of the generalized travel cost approach is to determine the attractiveness of a particular connection for passengers and the likelihood that a particular connection is chosen by passengers.

The results are summarized as follows;

1. The route choice probabilities are the highest for direct connections with regard to passengers departing from Japan. This is largely because, in the Japanese domestic markets, indirect connections face fierce competition from a large volume of direct connections of better quality. In this sense, Tokyo/Haneda, the largest domestic hub, is also the largest in the market shares, even after taking into account all indirect connections between Japan and World, followed by other main domestic hubs, such as Osaka/Itami, Nagoya/Chubu, Fukuoka, Sapporo/Chitose, in addition to Seoul/Incheon.
2. In the short-haul markets, such as between Japan and Japan and between Japan and Asia & Oceania, where connecting and circuity time of indirect connections are relatively large compared with direct connections of a higher quality with high frequencies, direct connections have a total market share of almost 100 %. Meanwhile, in the long-haul market

to Latin America, direct connections have much smaller shares, slightly less than 14 %. As for the markets between Japan and Europe and between Japan and Africa, approximately half of the business and leisure travelers choose an indirect connection. Around 30 % of all connections are indirect ones as for the markets between Japan and North America and between Japan and Middle East. Taking into account all markets (Japan-World), almost all connections are made directly, largely because the domestic markets are much larger compared with international ones.

3. In the markets between Japan and Japan and between Japan and World, the largest hub is Tokyo/Haneda, followed by Osaka/Itami, Nagoya/Chubu, Sapporo/Chitose, Fukuoka, Naha (Okinawa) and Osaka/Kansai. Among these domestic hubs are Seoul/Incheon and Shanghai/Pudong for the market between Japan and World. In the markets between Japan and Asia & Oceania and between Japan and World (excluding Japan), Seoul/Incheon is the largest hub, followed by Shanghai/Pudong. Tokyo/Haneda is ranked tenth in September 2010, meanwhile ranked sixth in March 2011. Other major Asian hubs, such as Pusan, Beijing/Capital, Dalian and Taipei/Taoyuan are ranked among other major Japanese hubs, Tokyo/Narita, Osaka/Kansai, Nagoya/Chubu and Fukuoka. As for the market between Japan and Europe, the European hubs, such as Frankfurt, Helsinki, Munich, Paris/Charles de Gaulle and Amsterdam are the most popular intermediate hubs. Seoul/Incheon is ranked

third both in September 2010 and in March 2011. Tokyo/Haneda is predicted to get a market share of more than 2 % in March 2011, owing to the opening of scheduled international services to European destinations. As for the market between Japan and North America, the main hubs in the United States are Chicago/O'Hare, San Francisco and Los Angeles. Among the Asian hubs, Tokyo/Narita is ranked second and Seoul/Incheon ranked eighth in March 2011. Tokyo/Haneda is ranked third in March 2011, owing to the opening of scheduled international services to North American destinations. The US hubs, such as Dallas-Fort Worth, Houston and Los Angeles, and Mexico City are dominant in the market between Japan and Latin America. Four hubs in Middle East, Dubai, Doha, Abu Dhabi and Istanbul, and three hubs in Asia, Seoul/Incheon, Beijing/Capital and Hong Kong are top six hubs in the market between Japan and Middle East. In the market between Japan and Africa, three hubs in Europe, Rome/Fiumicino, Paris/Charles de Gaulle and Frankfurt for a historical reason, and three hubs in Middle East, Istanbul, Dubai and Doha for a geographical reason connect this market well, on top of African main gateway, Cairo.

4. Seoul/Incheon is a dominant hub in all markets except between Japan and Latin America and between Japan and Africa. It is ranked first in the markets regarding Asia & Oceania and World (excluding Japan), ranked second in the market regarding Middle East, ranked third in the market regarding Europe, ranked fourth in the market regarding World and

ranked eighth in the markets regarding North America in March 2011, largely because of the strategic well-developed hub-and-spoke networks by Korean air carriers to Japan.

5. After the opening of scheduled international services at Haneda in October 2010, its market shares remarkably increase in the markets between Japan and Asia & Oceania (from top ten to top six), between Japan and Europe (from out of rank to top seventeen), between Japan and North America (from out of rank to top three) and between Japan and World (excluding Japan) (from top ten to top six), greatly owing to quite a lot of incoming domestic flights to Haneda connecting well to the newly started international flights outgoing to Asia & Oceania, Europe and North America.

The NetCost model will be useful for airports or airlines in the assessment of their network performance and particular market shares, as well as for benchmarking their competitive position vis-à-vis other airports or airlines. Furthermore, this model allows for much more detailed analyses. For example, it will be useful in forecasting the market shares of two respective national air carriers or the expected impacts on their revenues. Particularly, the possible trade-off between national airlines' interests and consumer's interests can be assessed by monitoring the relevant network indicators. It will also be useful in the relative assessment of network development of airports or airlines, and the forecast of the impact of particular network changes on the route choice probabilities and finally on the passenger volumes of airports. Korean air carriers, for example, are strategically developing their hub-and-spoke networks in Northeast Asia, especially to Japan and China. This may give some negative impacts on Japanese air carriers and Japanese economy, or positive impacts from the consumer's perspective. These analyses are, however, left for future research.

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Appendix A. Alliance Members, September 2010 and March 2011

Oneworld	Star Alliance	SkyTeam
American Airlines, British Airways, Cathay Pacific Airways, Finnair, Iberia Airlines, Japan Airlines, LAN Airlines, Malév Hungarian Airlines, Mexicana, Qantas Airways, Royal Jordanian Airlines	Adria Airways, Air Canada, Air China, Air New Zealand, All Nippon Airways, Asiana Airlines, Austrian Airlines, Blue1, BMI, Continental Airlines, Brussels Airlines, Croatia Airlines, EgyptAir, LOT Polish Airlines, Lufthansa, Scandinavian Airlines System, Shanghai Airlines, Singapore Airlines, South African Airways, Spanair, Swiss International Air Lines, TAM Airlines, TAP Portugal, Thai Airways International, Turkish Airlines, United Airlines, US Airways	Aeroflot Russian Airlines, AeroMéxico, Air France, Alitalia, China Southern Airlines, Czech Airlines, Delta Air Lines, KLM Royal Dutch Airlines, Korean Air, Vietnam Airlines

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