MEASURING TRANSFER PASSENGER SHARES AT HUB AIRPORTS: AN APPLICATION TO PASSENGERS DEPARTING FROM JAPAN

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Abstract: This paper presents the NetCost model, which translates airline network data into indicators expressing the attractiveness of specific routes for passengers. For each relevant connection, direct as well as indirect, the model determines the generalized travel costs, related to airfares, travel time and waiting time. These costs are translated into the relevant network indicators: consumer values and route choice probabilities. After providing an overview of the main features of the NetCost model, this paper estimated the route choice probabilities and the transfer passenger shares at major hub airports with regard to passengers departing from Japan. The results reveal that the route choice probabilities are the highest for direct connections departing from Japan, and Tokyo-Haneda is the largest hub, followed by other main domestic hubs like Osaka-Itami, Nagoya-Chubu, Fukuoka and Osaka-Kansai. Seoul-Incheon, however, was a dominant hub in the markets regarding Asia & Pacific, Middle East, Africa, Europe and North America, because of the strategic network developments by Korean air carriers to Japan. The model allows a comparison of network quality and market shares between several competing airports, as well as a monitoring of network quality and market shares of particular airports or airlines over time.

Key Words: NetCost Model; Generalized Travel Costs; Consumer Values; Route Choice Probabilities; Transfer Passenger Market Shares and Japan

1. INTRODUCTION

Hub-and-spoke network configurations become more and more developed in Asia. Airlines are increasing indirect flights at their hub airports, with the result of the increase in route and frequency. 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 the Japanese economy.

In 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 increase their flights or open new routes. Meanwhile, tag-end cabotage at Osaka-Kansai is being discussed. It is mainly because Japanese air carriers are suspending or decreasing their domestic flights at Kansai partly due to the economic recession in the Kansai area. Japanese government is seeking the possibilities to relieve Kansai by opening the domestic markets to foreign air carriers only in case of code-sharing with Japanese air carriers.

This paper presents the NetCost model which evaluates the quality of airline networks. The model translates airline network data (origin, destination, published carrier and number of operations) into indicators expressing the attractiveness of specific routes (and airlines) for passengers (consumers). 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 an indicator, expressing the perceived value for passengers. This results in route choice probabilities and market shares for each direct and indirect connection. The model allows a comparison of network quality and market shares between several competing airports, as well as a monitoring of network quality and market shares of particular airports or airlines over time.

After providing an overview of the main features of the NetCost model, this paper estimated the route choice probabilities and the transfer passenger shares at major hub airports with regard to passengers departing from Japan. In the end, the results will be expected to be useful for the assessment of network performance and hub competitive position in Northeast Asia.

2. ASSESSMENT OF NETWORK QUALITY

2.1 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 market shares of airlines or airports in certain markets. Figure 1 shows the scheme of the NetCost model.

Figure 1
Scheme of NetCost Model

2.2 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;

$$t_{xhy}^{total\ travel\ time} = t_{xy}^{flight} + t_{xhy}^{circuity} + t_{h}^{connecting} \tag{5}$$

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;

$$\mu_{xy} = 3 - 0.075 * t_{xy}^{flight} \tag{6}$$

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};

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

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 2. Waiting time still increases for lower frequencies, but not exponentially. The maximum waiting time now approaches 4 hours only.

Figure 2
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;

$$c_{xya}^{frequency} = VoWT * t_{xya}^{schedule\ delay} \tag{15}$$

(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) and Burghouwt et al. (2009).

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

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

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;

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

(19)

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

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

2.3 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;

$$U_{xhya} = e^{\rho * c_{xhya}^{total}} \quad (21)$$

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.

3. ROUTE CHOICE PROBABILITIES OF PASSENGERS DEPARTING FROM JAPAN

3.1 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 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 1 summarizes the assumptions on parameters in the model.

Table 1
Assumptions on Parameters to calculate Generalized Travel Costs

3.2 Data used and Classification of Study Area

The airline network data (origin, destination, frequency and travel time) are retrieved from OAG flight schedules in the third week of September, 2009. 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 year 2008, we distinguish three global airline alliances: 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, 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, and between Japan and World. The analysis considers the connectivity between all Japanese airports and airports worldwide or between all Japanese airports.

3.3 Results

Table 2 shows the market shares of direct and indirect connections in each market segment in the third week of September, 2009. In the short-haul markets, such as between Japan and Japan or between Japan and Asia & Oceania, direct connections accounted for over 95 percent for both travel purposes. In the long-haul markets to Latin America and Africa, direct connections had a smaller share, around 30~40 percent. As for the market between Japan and Europe, approximately half of the business and leisure travelers chose an indirect connection mainly via an European hub. Slightly more than 30 percent of all connections for both travel purposes were indirect ones as for the market between Japan and North America, mainly via the hubs in the

United States. This is largely because there are quite a lot of prospective destinations without direct connections, as well as quite well-developed indirect connections to these destinations in Europe and North America.

Table 2
Market Shares of Direct and Indirect Connections in each Market Segment, September 2009

The market shares of relevant hubs on indirect connections in each market segment are shown in Table 3. The first observation is that almost the same trends could be seen in the markets between Japan and Japan (domestic) and between Japan and World, owing to the huge domestic markets. The largest hub airport was Tokyo-Haneda, followed by Osaka-Itami, Nagoya-Chubu, Fukuoka, Osaka-Kansai, Okinawa-Naha and Sapporo-New Chitose. Among these domestic hubs were Seoul-Incheon and Shanghai-Pudong for the market between Japan and World.

In the market between Japan and Asia & Pacific, Seoul-Incheon accounted for more than 35 percent for both travel purposes, followed by Shanghai-Pudong (around 13 % for both travel purposes) and Osaka-Kansai (around 10 % for both travel purposes) purposes).

As for the market shares on indirect connections between Japan and Europe, Frankfurt and Paris-Charles de Gaulle, which accounted for around 13 percent for both travel purposes, respectively, were the most popular intermediate hubs. The striking finding was Seoul-Incheon ranked third among the top five European hubs, occupying more than 10 percent for both travel purposes. The following was Helsinki, occupying slightly over 10 percent for both travel purposes. Behind this is that Finnair has direct services to Tokyo-Narita (4 flights/week, daily from 2010), Osaka-Kansai (daily) and Nagoya-Chubu (4 flights/week), which are well connected to the rest of Europe at Helsinki.

As for the market shares on indirect connections between Japan and North America, the main hubs in the United States were Chicago-O'Hare (around 14 % for both travel purposes), San Francisco (9~12 % for both travel purposes), Los Angeles (7~8 % for both travel purposes) and Detroit (6~7 % for both travel purposes). Among the Asian hubs, Tokyo-Narita (around 9 % for both travel purposes) was ranked third, and

Seoul-Incheon ranked forth (approximately 7 % for both travel purposes).

Dallas/Fort Worth, Los Angeles and Houston were dominant in the market between Japan and Latin America, which together occupied a share of more than 60 percent of all indirect connections for both travel purposes.

Three Asian hubs, Seoul-Incheon (more than 35 % for both travel purposes), Hong Kong (10.5 % for leisure passengers and 8.0 % for business passengers) and Beijing-Capital (8~9 % for both travel purposes), and two hubs in Middle East, Doha and Dubai (slightly less than 9 % for both travel purposes in both hubs) were the top five hubs in the market between Japan and Middle East.

In the market between Japan and Africa, European hubs Paris-Charles de Gaulle (around 16 % for both travel purposes), Rome-Fiumicino (10~12 % for both travel purposes), Frankfurt (more than 7 % for both travel purposes) for a historical reason, and the hubs in Middle East like Istanbul (around 7 % for both travel purposes), Doha and Dubai (4~5 % for both travel purposes in both hubs) for a geographical reason connected this market well. Seoul-Incheon was ranked second with more than 15 percent of all indirect connections for both travel purposes.

The last observation is that Seoul-Incheon was a dominant hub in all markets except between Japan and Latin America (and between Japan and Japan). It was ranked first in the markets regarding Asia & Pacific and Middle East, ranked second in the market regarding Africa, ranked third in the markets regarding Europe and World, and ranked fourth in the market regarding North America, because of the strategic and well-developed hub-and spoke networks by Korean air carriers to Japan. Taking into account all indirect connections (the market between Japan and World), the domestic hubs such as Tokyo-Haneda (over 35 % for both travel purposes) and Osaka-Itami (over 15 % for both travel purposes) occupied the quite high market shares, reflecting the much larger domestic markets compared with international ones.

Table 3

Market Shares on Indirect Connections in each Market Segment, September 2009

In reality, there are often also direct connections available. These connections are of a higher quality, because they lack connecting and circuity time. Because of this, these direct connections obtain very high market shares. This is especially true over short distances, where connecting and circuity time of indirect connections are relatively large, compared with direct connections with high frequencies. In fact, in the markets between Japan and Japan (domestic), or between Japan and Asia & Oceania, direct connections had a total market share of almost 100 percent, because of many direct flights available.

When looking at the market shares of indirect connections in comparison with direct connections, it therefore makes sense to include only the direct connections that actually compete with the indirect connections. Table 4 shows these market shares in each market segment in the third week of September, 2009. 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, was also the largest in the market shares, even after taking into account all indirect connections between Japan and the world, followed by other main domestic hubs, such as Osaka-Itami, Nagoya-Chubu, Fukuoka and Osaka-Kansai, as shown in the market between Japan and World in Table 4. Among these domestic hubs was Seoul-Incheon (over 0.25 % for both travel purposes), which would be the results of strategic network developments by Korean air carriers to Japan.

Table 4

Market Shares excluding Direct Connections without Indirect Alternatives in each Market Segment, September 2009

4. 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 were 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, was also the largest in the market shares, even after taking into account all indirect connections between Japan and the world, followed by other main domestic hubs, such as Osaka-Itami, Nagoya-Chubu, Fukuoka and Osaka-Kansai.
2. In the short-haul markets, such as between Japan and Japan or between Japan and Asia & Oceania, direct connections accounted for over 95 percent for both travel purposes. In the long-haul markets to Latin America and Africa, direct connections had a smaller share, around 30~40 percent for both travel purposes. As for the market between Japan and Europe, approximately half of the business and leisure travelers chose an indirect connection mainly via an European hub. Slightly more than 30 percent of all connections for both travel purposes were indirect ones as for the market between Japan and North America, mainly via the hubs in the United States.
3. Seoul-Incheon was a dominant hub in all markets except between Japan and Latin America (and between Japan and Japan). It was ranked first in the markets regarding Asia & Pacific and Middle East, ranked second in the market regarding Africa, ranked third in the markets regarding Europe and World, and ranked fourth in the market regarding North America, because of the strategic and well-developed hub-and spoke networks by Korean air carriers to Japan.

The NetCost model will be useful for airports or airlines in the assessment of their network performance and their 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 route choice probabilities and finally on 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 B
Alliance Members, September 2008
Source: Made by authors

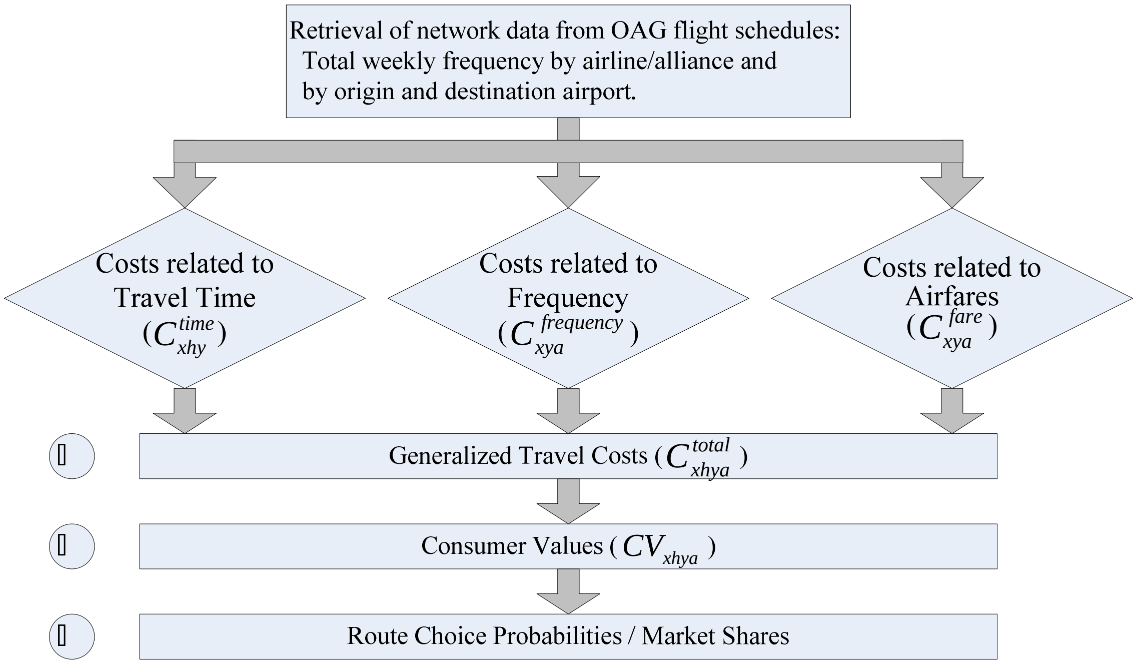

Figure 1. Scheme of NetCost Model

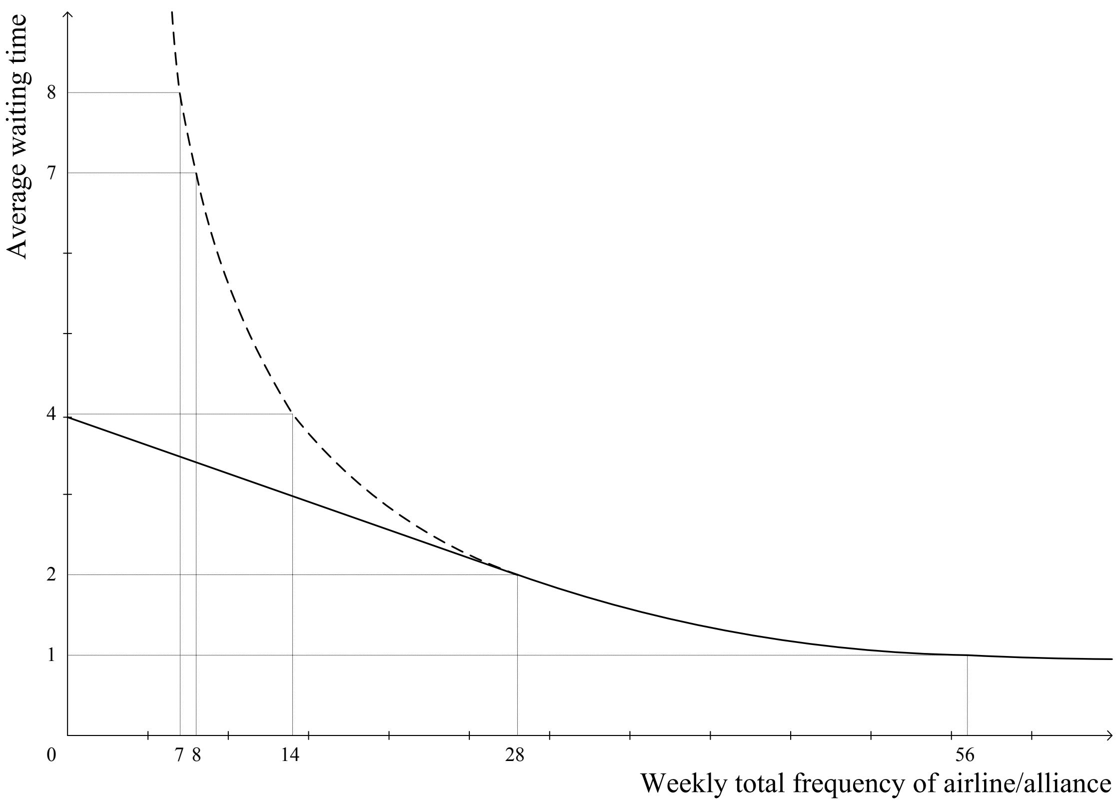

Figure 2. Average Schedule Delay as a Function of Frequency (before and after adjustments)

Table 1. 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)	

Table 2. Market Shares of Direct and Indirect Connections in each Market Segment, September 2009

Market Segment	Direct Connections		Indirect Connections	
	Leisure Passengers	Business Passengers	Leisure Passengers	Business Passengers
(1) Japan - Asia&Oceania	97.00%	96.62%	3.00%	3.38%
(2) Japan - Europe	48.90%	50.47%	51.10%	49.53%
(3) Japan - North America	67.12%	66.05%	32.88%	33.95%
(4) Japan - Latin America	32.25%	40.77%	67.75%	59.23%
(5) Japan - Middle East	56.03%	58.43%	43.97%	41.57%
(6) Japan - Africa	42.73%	42.01%	57.27%	57.99%
(7) Japan - Japan	99.46%	99.32%	0.54%	0.68%
(8) Japan - World	99.34%	99.17%	0.66%	0.83%

Table 3. Market Shares on Indirect Connections in each Market Segment, September 2009

(1) Japan - Asia&Oceania

Airport	Leisure	Business
ICN	**38.87%**	**37.24%**
PVG	12.63%	13.00%
KIX	**10.64%**	**9.56%**
PUS	7.34%	6.05%
FUK	5.93%	5.95%
NGO	**3.93%**	**3.77%**
PEK	3.63%	5.31%
TPE	3.28%	3.59%
CAN	2.54%	2.60%
HND	2.33%	2.64%
NRT	**2.03%**	**2.27%**
MNL	1.49%	2.23%
HKG	0.90%	0.96%
DLC	0.84%	0.79%
HIJ	0.81%	0.73%
SHA	0.71%	0.75%
BKK	0.43%	0.59%
GMP	0.31%	0.25%
SDJ	0.29%	0.25%
Others	1.09%	1.50%
Total	100%	100%

(2) Japan - Europe

Airport	Leisure	Business
FRA	13.49%	14.51%
CDG	12.73%	13.20%
ICN	**10.59%**	**10.25%**
HEL	10.05%	10.34%
AMS	6.65%	6.95%
LHR	5.96%	5.26%
PEK	4.83%	4.33%
MUC	4.79%	4.85%
SVO	4.72%	3.88%
CPH	4.28%	4.11%
NRT	**4.24%**	**4.41%**
VIE	3.81%	3.96%
FCO	3.50%	3.66%
ZRH	2.95%	2.74%
PVG	2.83%	2.57%
IST	1.78%	1.70%
NGO	**0.81%**	**1.02%**
KIX	**0.46%**	**0.82%**
Others	1.55%	1.44%
Total	100%	100%

(3) Japan - North America

Airport	Leisure	Business
ORD	14.74%	13.95%
SFO	9.69%	12.52%
NRT	**9.56%**	**8.75%**
ICN	**7.39%**	**6.19%**
LAX	7.10%	8.12%
DTW	6.98%	7.89%
TPE	5.72%	3.19%
MSP	5.19%	5.09%
DFW	4.65%	4.72%
DEN	4.21%	3.90%
ATL	3.73%	4.15%
SLC	3.35%	3.32%
YVR	3.24%	4.06%
IAD	3.20%	3.24%
YYZ	2.08%	2.12%
IAH	2.03%	2.11%
CVG	1.92%	1.76%
EWR	1.90%	1.88%
JFK	1.21%	1.13%
PVG	0.89%	0.62%
PEK	0.55%	0.44%
KIX	**0.44%**	**0.71%**
Others	0.22%	0.17%
Total	100%	100%

(4) Japan - Latin America

Airport	Leisure	Business
DFW	26.04%	23.78%
LAX	22.73%	13.34%
IAH	19.10%	24.06%
ATL	7.55%	9.61%
MEX	5.95%	10.82%
ORD	3.86%	2.99%
SFO	2.85%	2.19%
SLC	2.77%	2.03%
YYZ	1.92%	2.78%
EWR	1.66%	2.40%
DEN	1.35%	0.85%
DTW	1.25%	1.19%
NRT	**0.83%**	**1.70%**
JFK	0.77%	1.07%
Others	1.36%	1.20%
Total	100%	100%

(5) Japan - Middle East

Airport	Leisure	Business
ICN	**37.25%**	**35.16%**
HKG	10.52%	7.99%
PEK	9.36%	8.34%
DOH	8.86%	8.33%
DXB	8.50%	8.91%
BKK	6.34%	4.25%
CAN	3.51%	2.12%
DEL	2.87%	2.09%
IST	2.17%	8.23%
BOM	1.71%	1.38%
ISB	1.36%	1.38%
MNL	1.19%	0.93%
CAI	1.06%	1.60%
LHE	0.86%	0.88%
KHI	0.82%	0.83%
PVG	0.78%	1.61%
SVO	0.62%	1.07%
NRT	**0.42%**	**1.19%**
KIX	**0.36%**	**1.22%**
Others	1.44%	2.50%
Total	100%	100%

(6) Japan - Africa

Airport	Leisure	Business
CDG	16.40%	15.61%
ICN	**16.23%**	**15.35%**
FCO	12.72%	10.32%
FRA	7.80%	7.39%
IST	7.44%	6.38%
PEK	7.32%	6.62%
DOH	5.93%	4.67%
CAI	5.65%	11.33%
DXB	5.48%	4.56%
NRT	**3.40%**	**4.29%**
KIX	**2.73%**	**5.56%**
LHR	1.78%	1.35%
MXP	1.61%	1.27%
BKK	1.29%	0.99%
AMS	1.16%	0.98%
VIE	1.13%	0.99%
HKG	0.56%	0.81%
Others	1.36%	1.53%
Total	100%	100%

(7) Japan - Japan

Airport	Leisure	Business
HND	45.44%	46.73%
ITM	20.78%	20.15%
NGO	**9.26%**	**9.34%**
FUK	7.01%	7.03%
KIX	**4.91%**	**4.22%**
OKA	3.50%	4.20%
CTS	3.08%	3.23%
SDJ	2.21%	1.82%
KOJ	1.42%	1.30%
KMQ	0.87%	0.65%
KIJ	0.80%	0.68%
NRT	**0.48%**	**0.43%**
HIJ	0.23%	0.22%
Total	100%	100%

(8) Japan - World

Airport	Leisure	Business
HND	35.97%	37.04%
ITM	16.22%	15.73%
ICN	**8.50%**	**8.10%**
NGO	**8.09%**	**8.11%**
FUK	6.80%	6.82%
KIX	**6.16%**	**5.37%**
PVG	2.76%	2.83%
OKA	2.75%	3.30%
CTS	2.43%	2.57%
SDJ	1.78%	1.47%
PUS	1.62%	1.33%
KOJ	1.11%	1.01%
NRT	**0.82%**	**0.84%**
PEK	0.79%	1.16%
TPE	0.72%	0.78%
KMQ	0.68%	0.51%
KIJ	0.63%	0.53%
Others	2.17%	2.51%
Total	100%	100%

Table 4. Market Shares excluding Direct Connections without Indirect Alternatives in each Market Segment, September 2008

(1) Japan - Asia&Oceania

Airport	Leisure	Business
ICN	**1.54%**	**1.68%**
PVG	0.50%	0.59%
KIX	**0.42%**	**0.43%**
PUS	0.29%	0.27%
FUK	0.23%	0.27%
NGO	**0.16%**	**0.17%**
PEK	0.14%	0.24%
TPE	0.13%	0.16%
CAN	0.10%	0.12%
HND	0.09%	0.12%
NRT	**0.08%**	**0.10%**
MNL	0.06%	0.10%
HKG	0.04%	0.04%
DLC	0.03%	0.04%
HIJ	0.03%	0.03%
SHA	0.03%	0.03%
BKK	0.02%	0.03%
GMP	0.01%	0.01%
SDJ	0.01%	0.01%
Others	0.04%	0.07%
Direct	96.05%	95.48%
Total	100%	100%

(2) Japan - Europe

Airport	Leisure	Business
FRA	6.89%	7.18%
CDG	6.50%	6.54%
ICN	**5.41%**	**5.08%**
HEL	5.14%	5.12%
AMS	3.40%	3.44%
LHR	3.04%	2.61%
PEK	2.47%	2.14%
MUC	2.45%	2.40%
SVO	2.41%	1.92%
CPH	2.19%	2.04%
NRT	**2.17%**	**2.18%**
VIE	1.95%	1.96%
FCO	1.79%	1.81%
ZRH	1.51%	1.36%
PVG	1.44%	1.27%
IST	0.91%	0.84%
NGO	0.41%	0.51%
KIX	**0.24%**	**0.41%**
Others	0.79%	0.71%
Direct	48.90%	50.47%
Total	100%	100%

(3) Japan - North America

Airport	Leisure	Business
ORD	4.96%	5.01%
SFO	3.26%	4.50%
NRT	**3.22%**	**3.14%**
ICN	**2.48%**	**2.22%**
LAX	2.39%	2.91%
DTW	2.35%	2.83%
TPE	1.92%	1.14%
MSP	1.74%	1.83%
DFW	1.56%	1.69%
DEN	1.42%	1.40%
ATL	1.26%	1.49%
SLC	1.13%	1.19%
YVR	1.09%	1.46%
IAD	1.08%	1.16%
YYZ	0.70%	0.76%
IAH	0.68%	0.76%
CVG	0.65%	0.63%
EWR	0.64%	0.67%
JFK	0.41%	0.41%
PVG	0.30%	0.22%
PEK	0.19%	0.16%
KIX	**0.15%**	**0.25%**
Others	0.07%	0.06%
Direct	66.37%	64.10%
Total	100%	100%

(4) Japan - Latin America

Airport	Leisure	Business
DFW	18.62%	17.81%
LAX	16.26%	9.99%
IAH	13.66%	18.02%
ATL	5.40%	7.20%
MEX	4.26%	8.10%
ORD	2.76%	2.24%
SFO	2.04%	1.64%
SLC	1.98%	1.52%
YYZ	1.37%	2.08%
EWR	1.19%	1.80%
DEN	0.97%	0.64%
DTW	0.89%	0.89%
NRT	**0.59%**	**1.28%**
JFK	0.55%	0.80%
Others	0.97%	0.90%
Direct	28.49%	25.11%
Total	100%	100%

(5) Japan - Middle East

Airport	Leisure	Business
ICN	**16.50%**	**15.39%**
HKG	4.66%	3.50%
PEK	4.14%	3.65%
DOH	3.93%	3.65%
DXB	3.77%	3.90%
BKK	2.81%	1.86%
CAN	1.56%	0.93%
DEL	1.27%	0.91%
IST	0.96%	3.60%
BOM	0.76%	0.60%
ISB	0.60%	0.60%
MNL	0.53%	0.41%
CAI	0.47%	0.70%
LHE	0.38%	0.39%
KHI	0.36%	0.36%
PVG	0.34%	0.70%
SVO	0.27%	0.47%
NRT	**0.19%**	**0.52%**
KIX	**0.16%**	**0.53%**
Others	0.64%	1.10%
Direct	55.71%	56.24%
Total	100%	100%

(6) Japan - Africa

Airport	Leisure	Business
CDG	9.39%	9.05%
ICN	**9.29%**	**8.90%**
FCO	7.28%	5.99%
FRA	4.47%	4.28%
IST	4.26%	3.70%
PEK	4.19%	3.84%
DOH	3.39%	2.71%
CAI	3.24%	6.57%
DXB	3.14%	2.65%
NRT	**1.95%**	**2.49%**
KIX	**1.56%**	**3.22%**
LHR	1.02%	0.78%
MXP	0.92%	0.74%
BKK	0.74%	0.57%
AMS	0.67%	0.57%
VIE	0.65%	0.58%
HKG	0.32%	0.47%
Others	0.78%	0.89%
Direct	42.73%	42.01%
Total	100%	100%

(7) Japan - Japan

Airport	Leisure	Business
HND	1.25%	1.57%
ITM	0.57%	0.68%
NGO	**0.25%**	**0.31%**
FUK	0.19%	0.24%
KIX	**0.13%**	**0.14%**
OKA	0.10%	0.14%
CTS	0.08%	0.11%
SDJ	0.06%	0.06%
KOJ	0.04%	0.04%
KMQ	0.02%	0.02%
KIJ	0.02%	0.02%
NRT	**0.01%**	**0.01%**
HIJ	0.01%	0.01%
Direct	97.26%	96.65%
Total	100%	100%

(8) Japan - World

Airport	Leisure	Business
HND	1.06%	1.32%
ITM	0.48%	0.56%
ICN	**0.25%**	**0.29%**
NGO	**0.24%**	**0.29%**
FUK	0.20%	0.24%
KIX	**0.18%**	**0.19%**
PVG	0.08%	0.10%
OKA	0.08%	0.12%
CTS	0.07%	0.09%
SDJ	0.05%	0.05%
PUS	0.05%	0.05%
KOJ	0.03%	0.04%
NRT	**0.02%**	**0.03%**
PEK	0.02%	0.04%
TPE	0.02%	0.03%
KMQ	0.02%	0.02%
KIJ	0.02%	0.02%
Others	0.06%	0.09%
Direct	97.06%	96.44%
Total	100%	100%

Appendix A. Alliance Members, September 2009

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