

# Airport competition in terms of inter-network's relationship

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## 1. Introduction

It is informative for not only airport operators but also airport administrators to perceive how intense competition the airport faces.

So far, many researches which focus airport competition have been done. Many researches analyze and measure airport performance. Oum (2004) circumstantially reviews previous studies which focus on this issue. Park (2003) examines competitive strength of airports in East Asia. Park assumed that the competitive advantage of an airport depend on five core factors, which are special factors, facility factors, demand factors, service factors and managerial factors. And these core factors of investigated airports are separately analyzed. Finally, the airport competitive strength is measured with applying multi-decision criteria model. Meanwhile, Velduis (1997) develops connectivity index to identify the available service to travel from origin to destination. Connectivity from Amsterdam to other regions is calculated and competitive positions of airline networks are compared. However, the preference of passengers for air service is not considered in Velduis's study.

Meanwhile, Yeh (2003) pointed out that previous studies which analyze airport performance have been done only from the view point of airport managers. Then, he evaluates airport service quality from the view point of passengers. Yeh examines the competitive strength of airport with applying a fuzzy multiattribute decision making approach. Overall service performance index is developed and apply it to 14 major airports in Asia-Pacific region.

After reviewing previous studies, it becomes clear that there is no study to analyze intensity of the competition between certain airports and that there are few studies to analyze airport quality from the view point of passengers. Therefore, in this study the intensity between airports is examined with two indices (Competitive Index, Competitive index weighted with frequency), and also flight service at airport is evaluated from the view point of passengers with an index (Accessibility Index). Totally three indices is developed in this study and they are measured with the flight information data based on Official Airways Guide ('81,'87,'93,'04). And these indices are utilized to comprehend how intense competition an airport faces.

## 2. Data

Database of Official Airways Guide is used in this study. The data items extracted from the database are listed below.

- Origin and Destination,
- Operator of flight
- Number of operation per week
- Flight distance
- Number of competitors on O-D market

Meanwhile, airports investigated in this study are listed below.

- 12 airports in East Asia  
BKK, CGK, HKG, ICN, KIX, KUL, MNL, NRT, PEK, PVG, SIN, TPE
- 13 airports in Europe  
AMS, BCN, BRU, CDG, FCO, FRA, LGW, LHR, MAD, MUC, ORY, VIE, ZRH

### 3. Airport Competition

In this chapter, two indices are developed to explain the extent of intensity of competition between airports. One is a competitive index (CI) and another one is competitive index weighted with frequency (CIF). Concept of making indices, formulas and results of measurement are described.

#### 3.1. Competitive Index (CI)

##### 1) Formula

Method of measurement of CI is explained. Figure-1 is useful to understand the concept of network competition. There are two networks in the figure, which are network-A and network-B. Center of network is indicated by A and B in the figure.  $n_{ab}$  is the number of nodes connected to the both A and B and it is called as common node.  $n_a$  is the number of nodes connected to only A, and similarly  $n_b$  is the number of nodes connected to only B, they are called as exclusive node. Dummy nodes which represent A and B are added to simplify measurement of index, and they are counted within  $n_a$  and  $n_b$  respectively.

OD pairs which are considered to measure CI is shown in Table-1. The total number of OD pairs is calculated by (1).

$$2(n_a + n_{ab})(n_b + n_{ab}) \tag{1}$$

It is possible to move from one common node to any other node without passing through a link between A and B (link-AB). The number of combinations of such a type of OD pairs is calculated by (2).

$$n_{ab}(n_a + n_b + 2n_{ab}) \tag{2}$$

Moreover, it is possible to move from common node ( $n_{ab}$ ) to exclusive node ( $n_a$  and  $n_b$ ) without using link-AB, the number of such type of OD pairs is calculated with (3).

$$n_{ab}(n_a + n_b) \tag{3}$$

Therefore, the total number of OD pairs that one can move without using link-AB is determined by summing up equation (2) and (3). Then, CI is defined as a ratio of the number OD pairs without using link A-B for moving between nodes to OD patterns written by (4).

$$CI = \frac{n_{ab}(n_a + n_b + n_{ab})}{(n_a + n_{ab})(n_b + n_{ab})} \tag{4}$$

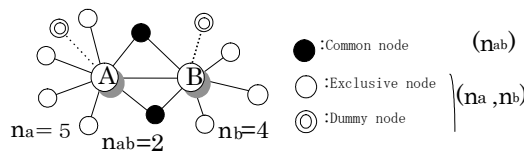


Figure-1 Concept of Competitive Index

Table-1 OD pattern considered to measure CI

	Exclusive node of A ( $n_a$ )	Exclusive node of B ( $n_b$ )	Common node in A side ( $n_{ab}^A$ )	Common node in B side ( $n_{ab}^B$ )
Exclusive node of A ( $n_a$ )		$n_a n_b$		$n_a n_{ab}$
Exclusive node of B ( $n_b$ )	$n_a n_b$		$n_b n_{ab}$	
Common node in A side ( $n_{ab}^A$ )		$n_b n_{ab}$		$n_{ab} n_{ab}$
Common node in B side ( $n_{ab}^B$ )	$n_a n_{ab}$		$n_{ab} n_{ab}$	

If there is no common node, i.e.  $n_{ab} = 0$ , a relation between network-A and network-B is complimentary competitive condition (CI=0), which is shown in the figure of left in Figure-2. Meanwhile, if every node is are connected to A and B, i.e.  $n_a = n_b = 0$ , the relation is perfectly competitive condition (CI=1), which is shown in the right figure in Figure-2.

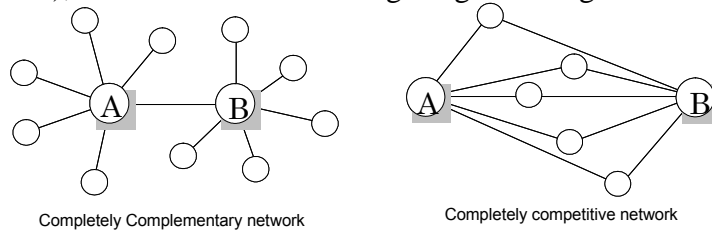


Figure-2 Extreme cases of network competition

## 2) Result of measurement

### a) Airport competition in East Asia

Competition in East Asia is examined in this section. Figure-3 shows the results of measurement of CI in 2004. The parenthetic value indicates the value of CI. Moreover, number of  $n_a, n_b, n_{ab}$  are also shown by colors of bar. Figure-3 shows the results of CI in 1981, 1993 and 2004. It is obvious that competitive condition has changed with time-passing. In the figure of 1993, it is indicated that there are two centers of airport competition. One is competition among Narita, Seoul and Taipei wherein the networks have spread to North America. The other is a competition among Singapore, Hong Kong wherein networks spreads mainly to South Asia region.

Meanwhile, competitive situation is changed in 2004. Drastic change of air transport network is shown as seen in figure. One of the reasons is that many large scale airports, such as Seoul Incheon airport, Shanghai Pudong airport and Honk Kong International airport, are successively opened. It causes drastic change of network structure in this region.

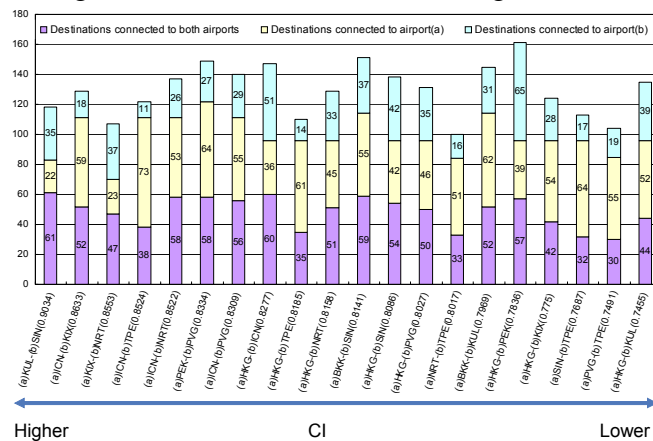


Figure-3 Measurement of CI in 2004

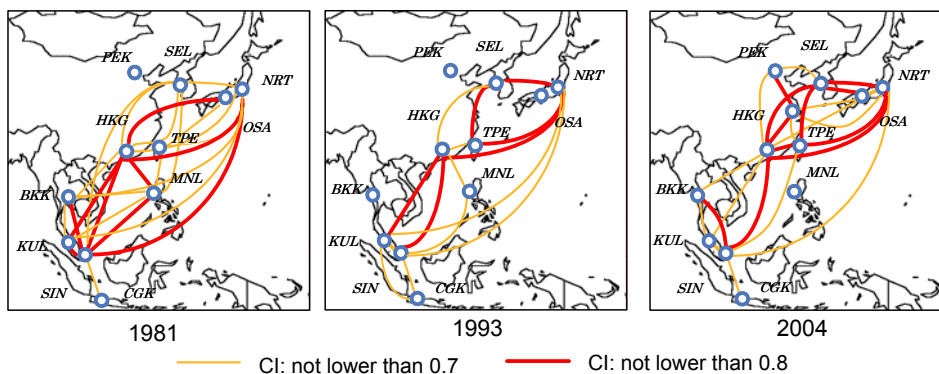


Figure-4 Transition of competitive situation from 1981 to 2004

## b) Airport competition in Europe

Results of measurement of CI for in Europe are shown in Figure-5 and -6. Most intensity competition is occurred between MAD and BAL. The reason is that a set of destinations from these airports is almost same. Meanwhile, competition FRA and ZRH, FRA and MUC, FRA and VIE is relatively intense. The reason is that a set of destinations of ZRH, MUC, VIE is almost overlapped by that of FRA. Figure-6 shows the airport competition where CI is relatively large.

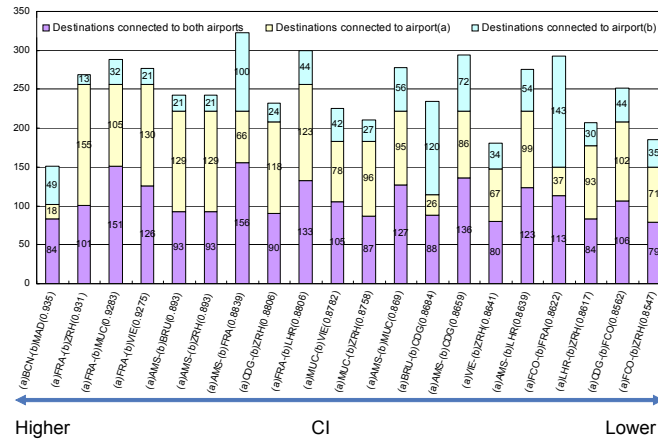


Figure-5 Measurement of CI in 2004

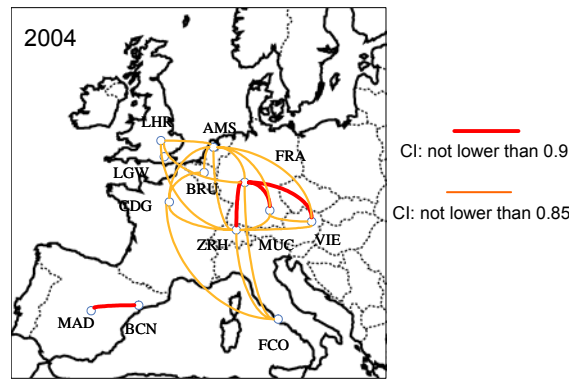
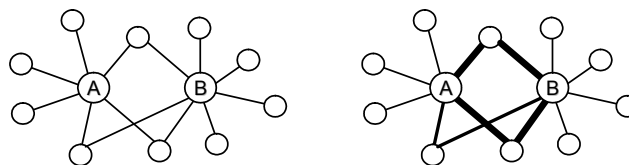


Figure-6 Intense of airport competition

### 3.2 Competitive Index weighted with Frequency (CIF)

CI explains competitive situation in terms of network structure. However, quality of transportation network depends on the level of service as seen in Figure-7. And the quality is certainly a main factor of airport competition. Therefore, an index which can explain the extent of network competition with considering quality of transportation service is developed in this section. Actually, frequency, fare level and required travel time should be considered to evaluate quality of service. However, only frequency is considered in this study because of data constraint.



Network structure is same, however the level of service of network is different, which is indicated by line width

Figure-7 Difference in quality of transport network

## 1) Formula

Method of measurement of Competitive Index weighted with frequency (CIF) is described below.

CIF is measured by (5)

$$CIF^{AB} = \sum_O \sum_D \min\{W_{OD}^A, W_{OD}^B\}$$

$$W_{ij}^l = \begin{cases} F_{ij}^l \\ \min\{F_{ik}^l, W_{kd}^l\} \end{cases} \quad (5)$$

$CIF$ : competitive index weighted with frequency

$W_{ij}^l$ : weight of airport l concerning market i-j

$F_{ij}^l$ : frequency on market i-j

k: transit airport k concerning market i-j

An example of calculation of the term of  $\min\{W_{OD}^A, W_{OD}^B\}$  is mentioned in Figure-8.

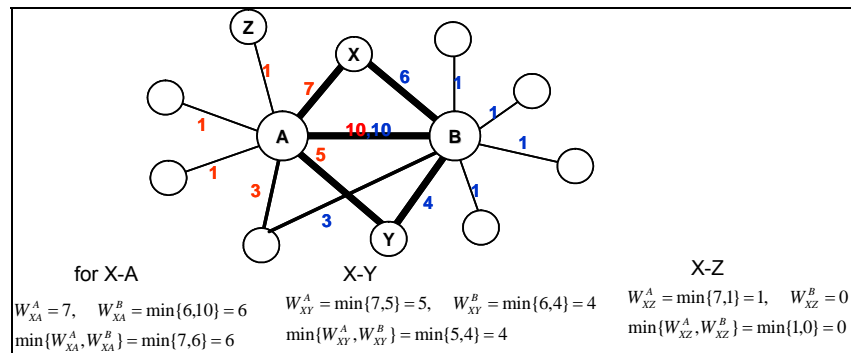


Figure-8 Example of measurement

## 2) Result of measurement

### a) Airport competition in East Asia

Figure-9 shows a result of measurement of CIF. The bar shows the value of CIF between airports, which are also mentioned in the figure. Competitions between PEK and PVG, BKK and SIN, ICN and NRT, KUL and SIN are ranked as most intensity competition in East Asia. Moreover, Figure-10 shows the airport competition where CIF is relatively large.

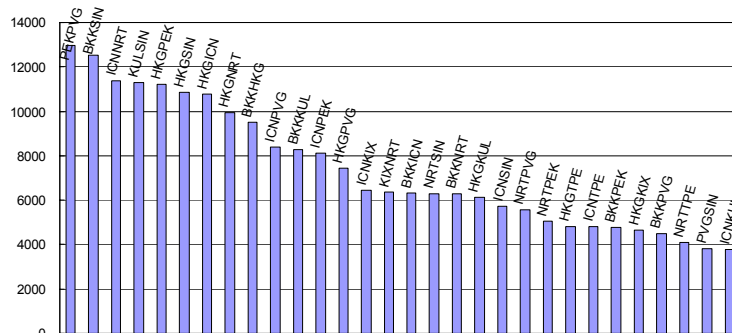


Figure-9 CIF (Airports in East Asia)

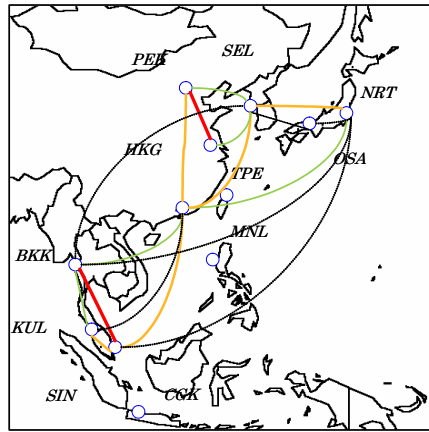


Figure-10 CIF (Airports in East Asia)

**a) Airport competition in Europe**

Figure-11 shows the result of measurement of CIF. Competitions between CDG and FRA, AMS and CDG, AMS and FRA, FRA and MUC are ranked as most intensity competition in Europe. Moreover, Figure-12 shows the airport competition where CIF is relatively large.

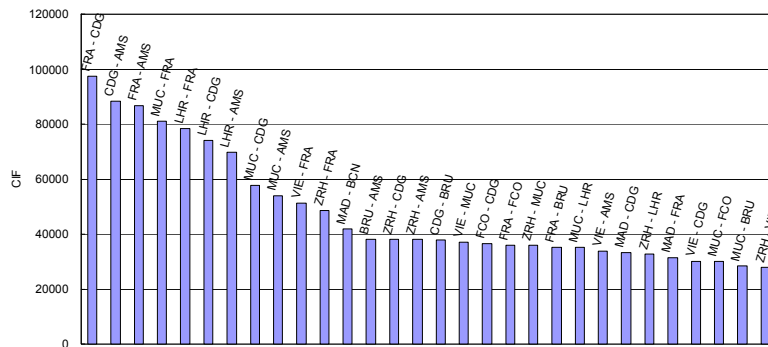


Figure-11 CIF (Airports in Europe)

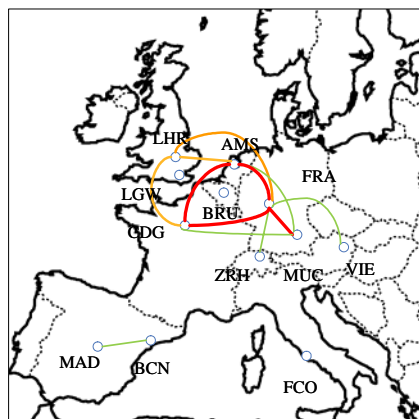


Figure-12 CIF (Airports in Europe)

**4. Accessibility of Airport**

As shown in former sections, expansion of air network induces intense competition. However, it also produces more convenient transport service from the viewpoint of passengers. In this chapter, the quality of service at certain airport is examined through a index which can explain the accessibility of air travel.

## 4.1 Definition of Accessibility

Accessibility is defined as easiness of air travel, which is improved by not only increase in number of destinations but also improvement in quality of service. In this context, accessibility is an indicator which can evaluate service of airport from the viewpoint of passenger. An index which can described level of accessibility of airport is developed in this chapter. And, the value of index is measured for major airports in Europe.

## 4.2 Formula

It is assumed that behavior of traveler follows a decision making process described below. First step is a step of trip generation. In this step, traveler decides to go to travel or not. Second step is a step of destination choice. In this step, traveler selects destination of travel among alternate destinations. Third step is a step of airline service choice. In this step, traveler select a air service to move to the destination selected in second step.

It is assumed that this decision making process is modeled with applying Nested logit model in this chapter.

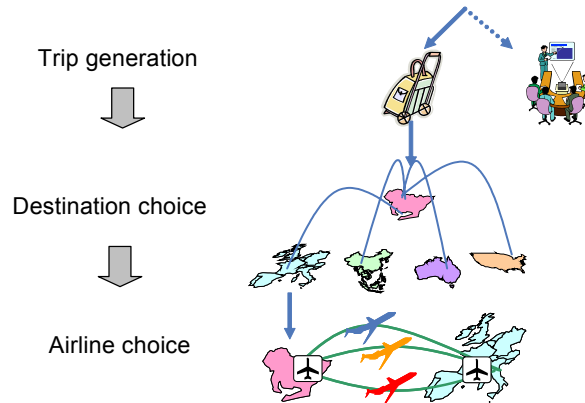


Figure-13 Hierarchy of Passenger's travel behavior

In the step of airline choice, utility of air service from origin (O) and destination (D) is written by (6).

$$V_{OD}^l = V_{OD}^l(freq_{OD}^l, fare_{OD}^l, ttime_{OD}^l, \dots) \quad (6)$$

$V_{OD}^l$  : utility of air service l on market OD

$freq_{OD}^l, fare_{OD}^l, ttime_{OD}^l$  : explanatory variables

Then, expectation of maximum utility is shown as (7)

$$LS_{OD} = \ln\left(\sum_l \exp(V_{OD}^l)\right) \quad (7)$$

$LS_{OD}$  : logsum utility for airline choice

Meanwhile, in the step of destination choice, utility of destination (D) is written by (8),

$$V_{OD} = V_{OD}(LS_{OD}, ATR_{OD}, \dots) \quad (8)$$

$V_{OD}$  : utility of destination D with fling from O

$LS_{OD}, ATR_{OD}$  : explanatory variables

$LS_O$  : logsum utility for destination choice

As seen in the function form, utility depend on logsum utility of airline choice.

Meanwhile, logsum utility of destination choice is shown as (9)

$$LS_O = \ln\left(\sum_D \exp(V_{OD})\right) = AI_O \quad (9)$$

And, the value of this logsum utility is defined as accessibility of airport, and it set as an index  $AI_O$ .

### 4.3 Results of measurement

Estimation of coefficients of utility function,  $V_{OD}^l$  and  $V_{OD}$ , should have been done in order to measure AI. However, in this study, the simplest function form is adopted to demonstrate the availability of the index.

#### a) Condition of measurement

It is assumed that  $V_{OD}^l$  depend on only frequency ( $freq_{OD}^l$ ). So, utility function of airline choice is written by (10)

$$V_{OD}^l = \alpha \cdot freq_{OD}^l \quad (10)$$

Meanwhile, it is assumed that  $V_{OD}$  depend on only logsum utility of airline choice ( $LS_{OD}$ ). So, utility function of airline choice is written by (11).

$$V_{OD} = \beta \cdot LS_{OD} \quad (11)$$

Then, AI is written in equation as shown in (12).

$$AI_o(\alpha, \beta) = \ln\left(\sum_D \exp(\beta \cdot \ln(\sum_l a \cdot freq_{OD}^l))\right) \quad (12).$$

Therefore, value of AI is increased with not only increase in number of destination and air service but also improvement of quality of air service. Coefficients  $\alpha$ ,  $\beta$  are weights which shown strength of preference for frequency and number of alternative destinations. In this study, the condition that  $\alpha + \beta$  is 0.1(constant). And several value of  $\alpha$  and  $\beta$  are set and the AI is measured in each case.

#### b) Result

Figure-14 shows the result of measurement of AI. Right side of horizontal axis indicates larger value of  $\alpha$ , which indicates that traveler puts much weight on quality of air service such as frequency. As seen in Figure-14, the value of AI of each airport is changed by setting different value of  $\alpha$  and  $\beta$ .

However, ranking is not drastically changed. FRA, CDG, LHR and AMS keep in high ranking at any cases.

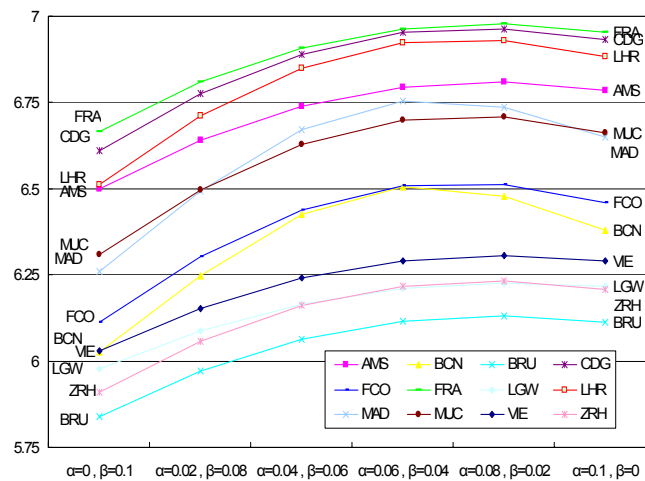


Figure-14 AI (Airports in Europe)

## 5. Conclusion and Discussion

Main works of this research are,

- to make an index which explain intensity of competition between specified airports
- to make an index which can compare the accessibility of airport from the view point of passengers.

These indices can be utilized to perceive the competitive situation of one airport.

Regarding to CI, the concept of calculus and has been made, Moreover, CI is u  
However, these indices

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