The impact of route network expansion on airport attractiveness: A case study of Chubu international airport in Japan

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ABSTRACT

This article looks at the impacts of the increase in international air routes on airport attractiveness to examine airport competition, through a case study of Chubu International Airport in Japan. Considering several determinants, such as travel time, air fare, population and propensity to travel by air to the destination, we develop a gravity model to evaluate the attractiveness of the Chubu airport in terms of short-, medium- and long-haul flights. Then, we forecast the effects of increase of Chinese destinations on potential changes. The results suggest that flights to China could increase Chubu's accessibility dramatically, but it would be difficult for Chubu to be as attractive as Narita. This model provides a method to calculate the critical number of cities to be connected by air flights to make the Chubu airport competitive with other airports.

Keywords: airport competition, attractiveness, gravity model, Japanese airport, route network

1. Introduction

The way an airport operator chooses air routes has a big impact on airport sustainable development. The potential demand at the airport includes the impact of existing routes and an assessment of newly stimulated traffic (Graham 2008). Air network construction creates new opportunities for airports to compete for passengers, flights and airlines. The city airports are limited in travel demand in their catchment areas but take leading roles in designing air routes. For example, Munich Airport handled flights to 229 destinations and 34.5 million passengers in 2008 (Munich Airport, 2009), although it only handled 10.8 million passengers in 1991, when it opened at a new location. As a consequence, the authors sought to investigate which kind of air route plan could enable the Chubu airport to achieve the same success as Munich Airport.

Nagoya Chubu Centerair International Airport (Chubu) is an offshore airport located about 40 km south of the city center of Nagoya in the Chubu region. Originally designed for 17 million passengers per year, Chubu's current passenger number is less than 10 million, with about 13,000 flights annually. As a consequence, Chubu needs another 7 million passengers fill up the extra capacity. On January 20, 2011, the Ministry of Land, Infrastructure and Transport (MLIT) announced that it would temporally lift the limit on the flight numbers between Chubu and China and said that it plans to open Kansai and Chubu airports to China completely in the near future.

It is the aims of this paper to estimate the attractiveness of Chubu with new flights to Chinese airports under Japan-China Open skies. The main data used in this study comes from Official Airline Guild lines, 2010.Taking the indicators, such as population size, travel propensity, travel distance, travel time, airfare and real GDP Per Capita of each Chinese urban agglomeration, the authors have improved a gravity model to examine the most efficient route networks between Chubu and China. There are 5 sections in this study. After the overview of international passenger traffic in Japan in section 2, Section 3 introduces the study area and Section 4 introduces is the method and the data used. Section 5 is the result and Section 6 is the discussion and conclusion.

2. Overview of international passenger traffic in Japan

In 2009, 27 out of 97 airports in Japan handled a total of about 15.4 million international passengers. Fig 1 shows the top 10 biggest international airports and illustrates a 'unipolar structure' airport system in Japan (Feldhoff, 2003). There is an obvious concentration of passenger volume in Tokyo's metropolitan airports –Tokyo International Airport (Haneda) and Narita International Airport (Narita). With its 28.12 million international passengers, Narita is the most important international airport, and Haneda is the leading domestic airport, with 59.33 million domestic passengers. Domestic aviation in Japan is dual-centric, with Haneda and Osaka International Airport (another Osaka metropolitan airport) as the two hubs (Barros, Managi, and Yoshida 2010), while Narita and Kansai only handle international flights and some domestic flights. Narita is not adequately integrated into the domestic air traffic system. In addition, most of the transfer passengers in Kansai have to make the time-consuming transfer to Osaka Airport to get domestic flights. By contrast, Chubu provides efficient passenger transfer between domestic and international flights, by merging international and domestic terminals in the same building, As a consequence, Narita and Kansai are very limited in domestic traffic, but Chubu enjoys a practical split between domestic and international passengers. The implication is that, compared with Narita and Kansai, Chubu is more competitive in increasing the rate of transfer passengers.

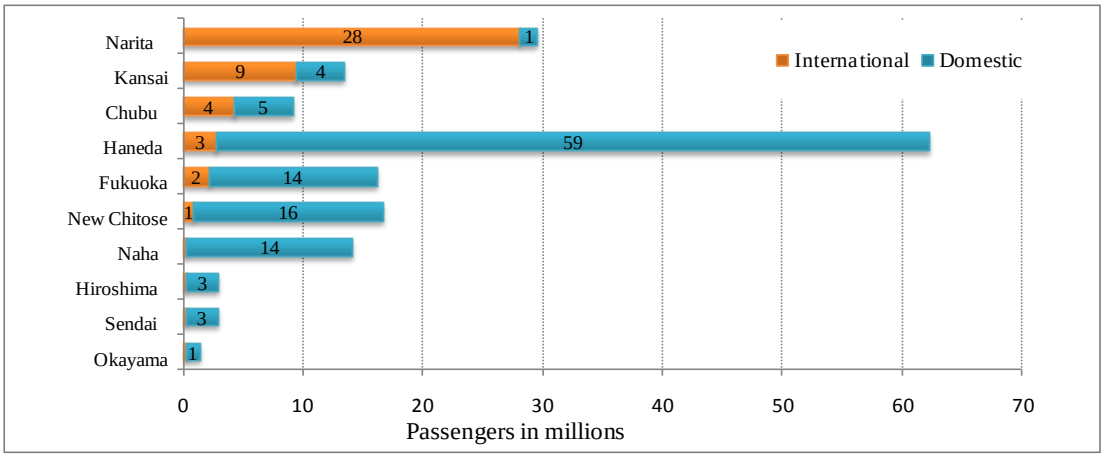

Fig. 1 Top 10 biggest airports in Japan by international passenger numbers in Japan, 2009

Table 1 shows that long-haul flights are predominant at Narita, with a few flights to Kansai, while Chubu operates only short- and medium-haul routes. Considering the geographical location of Japan as an island country, we consider distances less than 3,000 km (the great circle distance) as short-haul, 3,001- 6,000 km as medium-haul and more than 6,000 km as long-haul. According to this standard, international flights in Narita can be divided as follows: (1) 33 percent of flights are operated by Japanese carriers JL and NH to most destinations; (2) Non-stop long-haul flights are operated by EU or US carriers such as NW or LH; while stop-over long-haul flights between the US and Asia are operated by US or Asian carriers; (3) medium-haul flights to Asia, Australia and traditional resort destinations in the Pacific area; (4) short-haul flights operated by Asian airlines to China and Korea. Nevertheless, with the highest landing fee in the world, Narita has been operating at the limit of its capacity for many years. Using wide-bodied aircraft is the only way to achieve higher passenger volumes at this airport (Feldhoff, 2003; Givoni and Rietveld 2010). It is difficult for new carriers to fly narrow-bodied aircraft to Narita. Alternatively, those carriers who want to enter the Japanese international aviation market with smaller-size aircraft need to choose other airports.

Table 1

Distribution of international seats and routes in 2009

	Categories[1]*	Share	No. of flight per week	Airlines served	Main destinations
Narita	Major airport	56%	2262	51	US, China, Korea, EU, Australia
Kansai	Major airport	19%	368	40	China, Korea, US, EU
Chubu	Major airport	8.5%	240	21	China, Korea, Southeast Asia
Haneda	All others	5%	936	7	Korea, China
Fukuoka	All others	4.7%	242	15	Korea, China, Southeast Asia

1*: According to the 2008 New Airport Act, Japanese airports are classified into two categories: major international airport and all others.

Source: Travel Journal (2010)

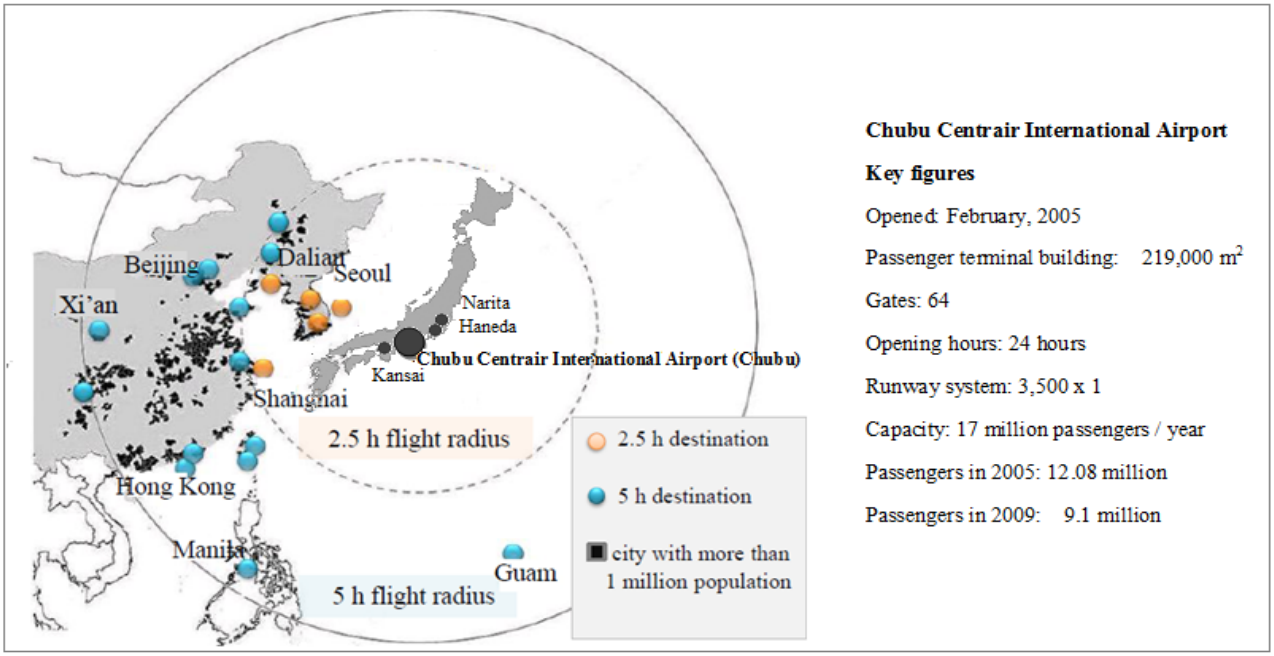

Fig. 2 Destinations and key figures of the Chubu Centrair International Airport (Chubu)

3. Study area

Nagoya Chubu Centerair International Airport (Chubu) is an offshore airport located about 40 km south of the city center of Nagoya in the Chubu region. This region is one of Japan's major economic regions, with a population of approximately 22 million and accounting for about 18% of Japan's GDP. With passengers transferred from the old Nagoya Airport, the Chubu airport started operation in 2005 as the major airport for the Nagoya Metropolitan area. In 2009 Chubu handled 4.96 domestic passengers to 22 domestic destinations and 4.14 million international passengers to 25 international destinations. China was the main destination. Fig 2 shows international destinations within five-hour flight radius of Chubu and suggests that China is the main market. There was a 25 percent decrease in number of passengers from 2005 to 2009, probably due to the worldwide economic downturn and fierce competition among the major airports in Japan.

While Chubu has competed with Narita, Kansai and Haneda for the position as a gateway airport to Asia, in fact, it acts as a regional airport handling spoke-to-spoke flights rather than a hub

server. Chubu has not managed to attract the volume of traffic that was forecast. Originally designed for 17 million passengers per year, Chubu's current passenger number is less than 10 million, with about 13,000 flights annually. As a consequence, Chubu needs another 7 million passengers with about 10, 000 flights annually to fill up the extra capacity. On January 20, 2011, the Ministry of Land, Infrastructure and Transport (MLIT) announced that it would temporally lift the limit on the flight numbers and frequency between Chubu and China, with the intention of attracting more Chinese leisure tourists to visit Japan. In line with the Asian Gateway Initiative, MLT said that it plans to open Kansai and Chubu airports to China completely in the near future.

This is the background for our study. The aim of this paper is two-fold: to analyze current attractiveness of the Chubu Airport by comparing it with Narita Airport; and to project the future of Chubu if China's market effect is considered. In particular, a gravity model is developed to estimate the air network between Chinese cities and Chubu to build a more competitive Chubu Airport.

4. Data and model

4.1 Data used in this study

Table 2 shows the eight kinds of data that have been used in this paper, which are collected from many sources. We consider all of these cities which connected with Narita and Chubu by direct flights as pairs of origin and destination. The general data of airlines of each O/D, such as flying time and seat supply are assessed from OAG. The fares of each O/D were priced on July 9th 2010 through Airlines' internet booking system. We selected the lowest available fares (both of economic and business class) for roundtrip departure from Narita or Chubu on September 3rd, 2010. The population data of each destination is assessed from UN. Real GDP per capita in China is provided by China Statistic Bureau. Airbus has produced a chart showing the relationship between propensity to travel and GDP per head of population in Global Market Forecast 2010-2029.

Table 2

Data used in this study

Data	Year	Source	Remark
Air fare	2010	Airlines	We selected the lowest available fares (both of economic and business class) for roundtrip departure from Narita or Chubu on September 3rd, 2010.The fares were priced on 9th July 2010 through internet booking system of each Airlines
Flying time	2010	OAG	Flying times of O/D without non-stop flight are based on route: Nagoya – Dalian, Beijing or Shanghai – destination, shortest one was selected
GDP per capita	2009	Yearbook	China City Statistical Yearbook 2010
Population	2009	UN	World Urbanization Prospects: The 2009 Revision Population Database (UN 2010)
Seat supply	2010	OAG	Official Airline Guide flight guide worldwide (2010)
Propensity to travel	2009	Airbus	Airbus has produced a chart showing the relationship between propensity to travel and GDP capita in 2010.This takes into account the issues of passengers originating in a particular country by using the IATA PaxIS tool which uses Bank Settlement Plan data as its main source of information. In 2009 Chinese propensity for air travel was 0.11 trips

4.2. Model

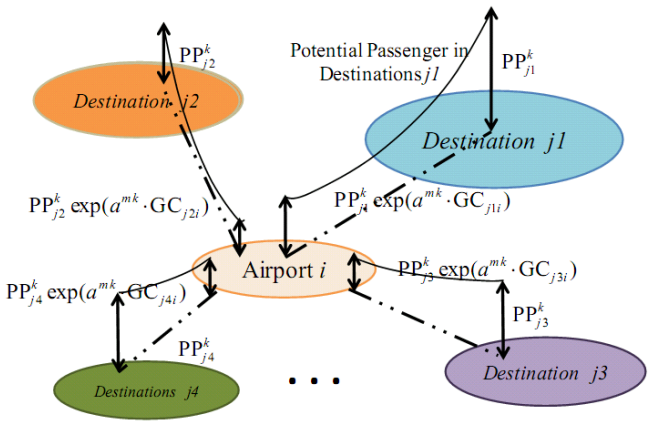

Fig 3 Gravity model applications in airport attractiveness study

Gravity models are commonly used in transport research (Grosche et al. 2007). Doganis (2004) forecast scheduled passenger traffic by using factors of economy class fare and flight frequency. In this paper we use the factors of population, travel propensity, travel distance, travel time and airfare as independent variables to project the economic potential of Chubu (Fig. 3). Furthermore, we take economic potential of place *i* as the attractiveness factor. A gravity model is proposed as follows:

$$A^i = \sum [PP_j / \exp(\alpha \times GC_{ji})] \quad (1)$$

Where, A^i is the attractiveness factor of origin *i;* PP_j is the amount of potential passengers who can travel by air from the destination city *j* estimated by the Eq. (2)

$$pp_j = \frac{d}{1 - b\mathrm{e}^{-cY}} \quad (2)$$

Where, *b*, *c*, *d* are parameters estimated from historical data (Airbus 2010). α is a distance decay parameter, which is estimated by the Eq. (3) (Frost and Spence, 1995; Gutierrez, 2001).

$$\alpha = -\ln\left(\frac{TP_{ji}}{O_i D_j}\right) \Big/ GC_{ji} \quad (3)$$

Where, TP_{ji} is the number of trips between origin *i* and destination *j*; O_i is the size of origin location *i* (e.g. total number of trips to commuters in origin *i*), D_j is the size of destination area (e.g. total number of work places in destination *j*). GC_{ji} is the weighted average generalized transport cost from prefecture *j* to *i*, which is measured by:

$$GC_{ji} = \sum_{n \in N} s_{ji}^n \cdot (F_{ji}^n + \omega^n \cdot t_{ji}^n) \quad (4)$$

where *n* denotes air carrier; s_{ji}^n is the market share of *n* in the total seat supplement from between *j* and *i*; F_{ji}^n is average air transport fare of carrier *n* from *j* to *i* in JPY; t_{ji}^n is travel time time of carrier *n* from *j* to *i* in minute; ω^n is time value of air transport in JPY/min.

5. Results

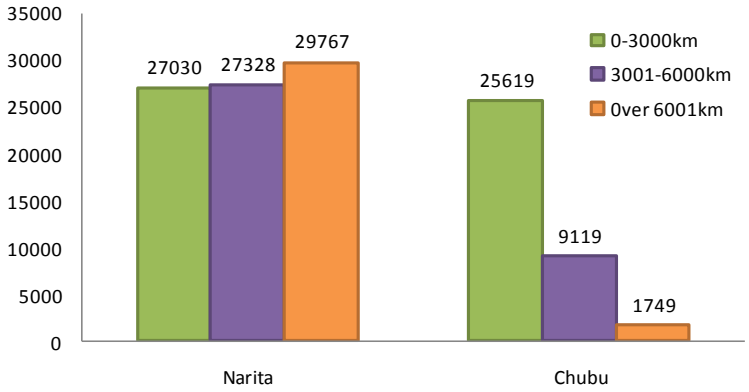

Fig. 4 Attractiveness of Narita and Chubu by route distance in 2010

5.1 Attractiveness of Chubu compared with Narita with current routes in 2010

The result suggests that the current attractiveness of Narita is higher than Chubu. If we take attractiveness of Narita as 1, Chubu is 0.4337. Fig 4 illustrates the result in term of short, medium and long haul route. (1) Chubu is almost as attractive as Narita for short- haul routes. This is probably due to the facts that flying distance and time from Chubu to Asian destinations are shorter than from Narita. For example, the flying distances from Chubu to Seoul, Shanghai and Beijing are 928 km, 1,509 km and 1,872km; respectively, while the distances from Narita to those destinations are 1,160 km, 1,777 km and 2,093 km, respectively. Table 3 shows that flying times from Chubu to Asian destinations are on average 30 minutes shorter than from Narita. (2) Medium-haul routes contribute significantly to increasing the attractiveness both of Narita and Chubu; and (3) long-haul routes have increased Narita's economic potential more than Chubu's.

Table 3
International routes and its Narita and Chubu in terms of short-, medium- and long-haul routes

	Narita International Airport			Chubu International Airport		
	Short-	Medium-	Long-	Short-	Medium-	Long-
Average Distance (km)	2,083	4,742	8,926	1,788	4,260	8,482
Average flying time (hours)	3.6	7.3	11.5	3.3	6.6	10.3
Share by no. of seat	42%	16%	42%	71%	15%	14%
Share in Economic Potential	32%	33%	35%	70%	25%	5%

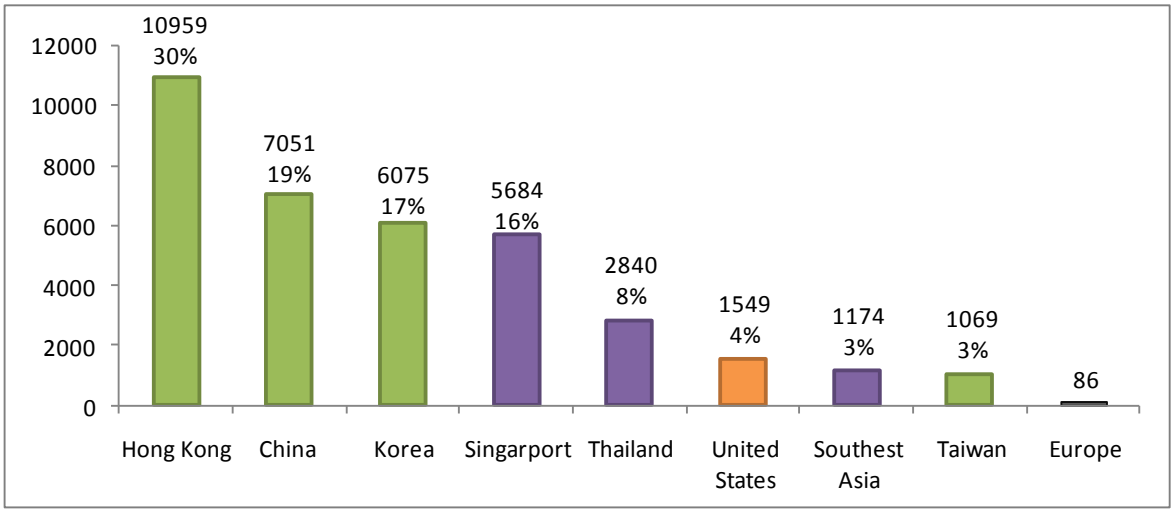

Fig. 5 Attractiveness of Chubu by destination in 2010

The Chubu airport serviced 25 destinations to 12 countries/regions. Fig. 5 shows the attractiveness contributed by each country and region. While with only 9.4 percent share of seat departures at Chubu, Hong Kong is the top destination by contributing 30 percent of the attractiveness of the airport. Partly due to Hong Kong people's high propensity for air travel of and lower fare level for the Nagoya-Hong Kong route (table 4). As the World's Best Airport 2011, Hong Kong International Airport (HKIA) aims to build up its hub position in Asia by attracting transfer passengers. From 2005 to 2009, connecting traffic at this airport grew twice as fast as non-stop traffic (Airbus, 2010). In 2010, Hong Kong airport handled about 50.9 million passengers, and served approximately 160 destinations. By contrast, mainland China occupied nearly 23.7 percent share of the seat departures at Chubu, but only contributed 17 percent to the attractiveness, probably due to the heavy impacts of low propensity for air travel (average around 0.11 air trips were made per person per annum in 2009) and relative high level of fares.

Table 4

Average fares by distance of top 3 destinations in Chubu

	Hong Kong	China	Korea
Average Distance (km)	2617	1961	869
Average fare for round trip (JPY)	63700	54000	39300
Average fare JPY/km	12.17	13.77	22.61

5.2 Potential of Chubu with new routes to China

In order to optimize the air traffic networks to increase airport attractiveness, four kinds of air networks were modelled. The authors calculate air fares, flying distance and time using various considerations such as air route, entrance gate, and domestic air fare to model the networks. Calculation of aircraft seats in models A, B, C was based on the assumptions that these routes would be operated by B757s with 8 business and 192 economic seats or comparable aircraft (the current aircraft that used for the Nagoya-China route is B738, Boeing 757 or Air Bus 320). Table 5 shows the details of each model and Fig 6 shows the result of each model in increasing the potential of Chubu Airport.

Table 5

Description of models

	Description of models
Model A	Introduced daily flights from Chinese airports located in urban agglomerations with 0.75 million inhabitants or more to the Chubu airport.
Model B	Established daily flights from Chinese airports that carried more than one million passengers in 2009 to Chubu.
Model C	Daily flight from airports located in urban agglomerations with 0.75 million or more population who have air travel demand
Model D	Doubled air traffic between China and Chubu by increasing current flight capacity or frequency

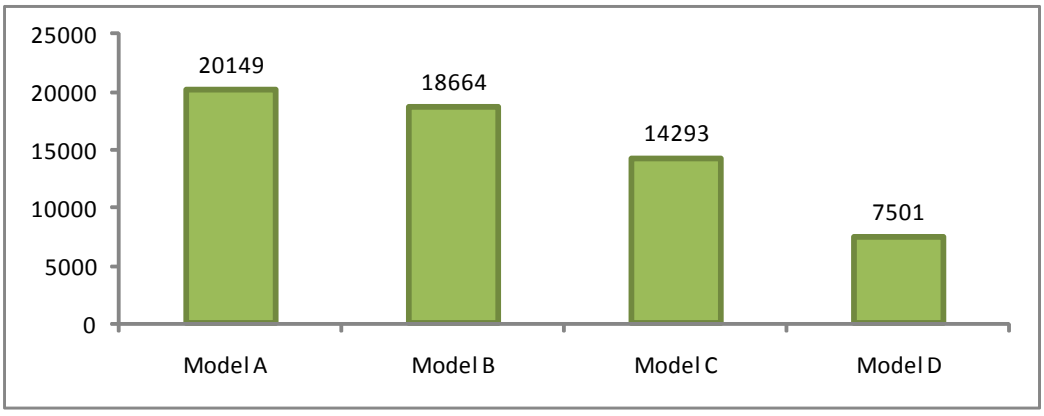

Fig. 6 Attractiveness of four networks

According to each route's efficiency, the total amount of increased attractiveness and other related indicators, model B and model C are probably appropriate networks for the Chubu airport. First, model B is more effective than model A because of the following two reasons. (1) The attractiveness of each route in network B is 373, which is 46% higher than in network A (Table 6). (2) 79 destinations (including 9 existed destinations in 2009) were selected to set up model A. However, in fact, it is difficult to attract international flights from all of these selected locations due to airport facilities problems or military control in China. On the other hand, airports selected for network B are almost all international airports or will be open to international flights soon. Second, while the route efficiency of model C is somewhat lower than that of model D, the result shows that network C could increase airport economic potential significantly more than network D (table 10). There are 18 destinations in model C: Eight existing destinations in 2009 (Beijing, Guangzhou, Shanghai, Chengdu, Xi'an, Qingdao, Dalian and Shenyang) and 9 new destinations: Shenzhen, Hangzhou, Chongqing, Xiamen, Wuhan, Wuxi, Baotou, Foshan and Nanjing.

Table 6
Attractiveness of Chubu with different networks

	Network A	Network B	Network C	Network D
No. of destination	79	50	18	9
attractiveness of each route	255	373	794	799
attractiveness of all routes	20149	18664	14293	7015
attractiveness of Chubu with new routes	56636	55151	50780	43,495

6. Conclusion

This paper estimates the current attractiveness of the Chubu airport, and projects to what extent the airport economic potential would be increased with new routes to China. Taking population size, travel propensity, travel distance, travel time, airfare and GDP per capita of each Chinese urban agglomeration as indicators, the authors constructed a gravity model to examine the most efficient flight network between the Chubu and China. The results of this study are: (1) Current attractiveness

of Chubu is 57.6 percent lower than Narita. However, Chubu is almost as attractiveness as Narita in short haul route due to flying distance and time from Chubu to Asian destination is shorter than from Narita. (2) Chubu could increase its attractiveness significant if attracted enough flights from China. Chubu could be developed sustainably if it attracted daily flights from 50 Chinese airports which each handle over one million passengers. Alternatively, it should attract daily flights from Beijing, Guangzhou, Shanghai, Chengdu, Xi'an, Qingdao, Dalian, Shenyang, Shenzhen, Hangzhou, Chongqing, Xiamen, Wuhan, Wuxi, Baotou, Foshan and Nanjing.

Certainly, these new flights would bring both aeronautical and non-aeronautical income, such as landing fee or duty-free shopping. More importantly, it might further enhance the airport's attractiveness for long-haul carriers by providing good flight connectivity and efficient passenger transfer. Elements such as available capacity, shorter distance to Asia or Europe, less marketing competition, fewer noise restrictions and lower operation fees, bring Chubu some advantages compared with the other two offshore airports - Kansai and Haneda. Meanwhile, shortage of landing space in Narita and aviation liberalization would encourage more carriers to make use of Chubu, just as capacity constraint at Frankfurt has forced new and independent carriers to make use of Munich Airport since the 1990s. In the future we plan to improve the model to analyze economic, business and industry factors of destinations with a full panel of data.

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