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AIR NETWORK PERFORMANCE AND HUB COMPETITIVE POSITIION: EVALUATION OF PRIMARY AIRPORTS IN EAST AND SOUTHEAST ASIA

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Abstract: The growth of hub-and spoke operations has changed the competition among airlines and airports in a structural way. In this paper, the argument is put forward that the measurement of network performance in hub-and-spoke systems should take into account the quantity and quality of both direct and indirect connections. The NetScan model, which quantifies an indirect connection and scales it into a theoretical direct connection, is applied to analyze the competitive position of airports in an integrated way. Measuring and comparing the network performance and the hub connective performance of thirteen selected primary airports in East and Southeast Asia between 2001 and 2007 is to be elaborated in this paper. The results reveal that Tokyo/Narita has the largest total connectivity, which is composed of direct and indirect connections. It is also the most competitive with respect to hub connectivity and average hub connectivity. The most striking growth of network developments, however, can be found at the three major airports in Mainland China; Beijing, Shanghai and Guangzhou. The number of both direct and indirect connectivity at these three airports increased at a much higher rate between these years than at other airports. On the contrary, others, such as Osaka/Kansai and Taipei, experienced deteriorating network performance. This analysis made here may be helpful for airlines and airports in identifying their network performance and competitive position in relation to competing counterparts.

Key Words: Network performance; Hub connective performance; Competitive position of airports; NetScan model and East/Southeast Asia.

JEL-code: L93

1. INTRODUCTION

Problems of hub location in international air transportation have drawn much attention in East and Southeast Asia. In this region, liberalization in international aviation and formation of global airline alliances have stimulated hub-and-spoke networks more and more. This region has witnessed intense competition among major airports to become key traffic hubs for international air transportation. Especially after the 1990's, new international airports opened one after another in this region: Shenzhen (1991), Osaka/Kansai (1994), Macau (1995), Kuala Lumpur (1998), Hong Kong (1998), Shanghai/Pudong (1999), Seoul/Incheon (2001), Guangzhou (2004), Nagoya/Chubu (2005), Tianjin (2005) and Bangkok (2006). Others, such as Tokyo/Narita, Singapore and Taipei, have expanded their runways or terminals. Beijing is also announced to start constructing a new international airport in 2010.

There have been plenty of studies on hub location problems in the US domestic market. Since the Airline Deregulation Act (ADA) in 1978, a lot of research has been conducted in the field of operations research to optimize air networks spatially by solving hub location problems and to forecast prospective domestic hub sites from the cost minimizing approach (O'Kelly, 1986; O'Kelly, 1987; O'Kelly & Yong, 1991; Kuby & Gray, 1993; O'Kelly & Miller, 1994; Daskin, 1995; O'Kelly, Bryan, Skorin-Kapov & Skorin-Kapov, 1996; O'Kelly, 1998; O'Kelly &

Bryan, 1998; Bryan & O'kelly, 1999). Some studies tried to predict prospective hub sites in the US domestic market from an empirical point of view. Schwieterman (1988), for example, investigated the factors behind direct connections, taking into account variables such as market size, flying distance etc. Huston and Butler (1991) examined the possibilities of major airports to be selected as airline hubs in the US domestic market by including variables such as population, income, education level, the accumulation level of enterprises and measures of city characteristics such as location advantages and climate.

There have been only a few studies, on the other hand, on hub location problems in international air transportation. After Hansen and Kanafani (1988) first took up this issue, some research has analyzed airports from the viewpoint of airline hub location. Berechman and de Wit (1996) evaluated the five primary West European airports as a main gateway hub in this region. With regard to Asia, Hansen and Kanafani (1990) explored the competitive position of Tokyo/Narita over the transpacific market from an economic standpoint. Schwieterman (1993) analyzed the eight major airports in this region for a prospective hub site of express air cargo in terms of airport capacity, location advantage, market size, terminal service and government policy. Ohashi, Kim, Oum and Yu (2005) focused on Northeast Asia and took up the five airports in this region to compare them from the standpoint of intercontinental air cargo transshipment airport. Matsumoto (2004) and (2007) evaluated the worldwide primary airports, including those in Asia, by using a gravity model in terms of international urban systems.

These studies, however, have focused on the demand aspect and did not capture air network structures, schedule coordination and the resulting hub performance from the supply-aspect. Consequently, work has been conducted to include the level of schedule coordination in the measurement of performance and structure of hub-and-spoke networks (Dennis, 1994a; Dennis, 1994b; Burghouwt, Hakfoort & Ritsema-Van Eck, 2003; Burghouwt & de Wit, 2005). Veldhuis (1997) analyzed Amsterdam/Schiphol focusing on the quality and frequency of connecting flights. Burghouwt and Veldhuis (2006) evaluated the competitive position of West European airports in the transatlantic market from this viewpoint. De Wit, Veldhuis, Burghouwt and Matsumoto (2007) took up four major airports in Japan and Korea and compared them in terms of network performance for passengers from/to Japan.

The main objective of this article is to extend this approach to East and Southeast Asia by measuring and comparing the performance of airline networks and hub connective performance of thirteen selected primary airports in this region between 2001 and 2007. After classifying network connectivity into three; direct, indirect and hub, this paper introduces a variable (Connectivity Units; CNU's) and applies the so-called NetScan model. The NetScan model counts the number of connecting opportunities and weighs these connections in terms of transfer and detour time. The model allows us to benchmark the competitive position of hub airports in

East and Southeast Asia.

2. OUTLINE OF PRIMARY AIRPORTS IN EAST AND SOUTHEAST ASIA

2.1 Development Schemes at Primary East and Southeast Asian Airports

New international airports opened in this region one after another, especially in the 1990's. Some airports are now expanding their current capacity to accommodate the rapidly growing air traffic demand, so that they can have an advantage over others in the airport competition. Figure 1 shows the current capacity and the future development schemes at the major airports in this region, which will be taken up for the analysis below.

Tokyo is now extending one of its runways (2,180 meters), which was in use in 2002, to 2,500 meters. Osaka completed the second scheme in 2007, having its second runway. In the final stage at Seoul and Bangkok, the construction of two additional runways is included. Shanghai opened its third runway and its second terminal building in March, 2008. The second scheme will start at Guangzhou in 2009, which will double the current airport area. Hong Kong and Singapore opened their second and third terminal building in March, 2007 and in January, 2008, respectively. Taipei also plans to build a third terminal building. Kuala Lumpur is the largest airport in Asia with four runways in its final scheme. Finally, Beijing is announced to start constructing a new international airport in 2010.

Shanghai (PVG)	
Current	Final
1999	—
1,252	3,200
3,400m x 1 3,800m x 1 4,000m x 1	4,000m x 5
280	800
224	—

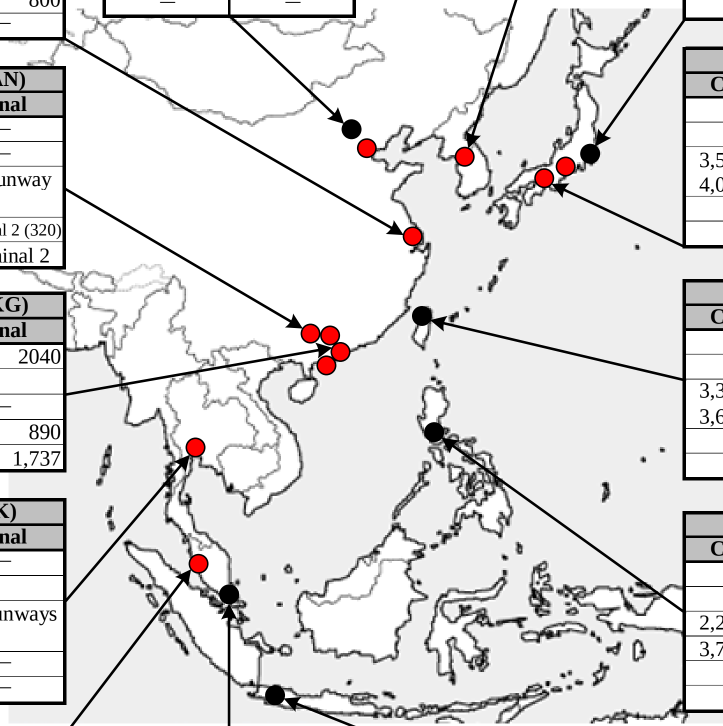
Beijing (PEK)	
Current	New Airport
1958 (1999)	2015
—	—
3,200m x 1 3,800m x 2	—
3 Terminals	—
—	—

Seoul (ICN)	
Current	Final
2001	2020
1,174	4,744
3,750m x 2	+ 4,000m x 2
343	875
132	858

Tokyo (NRT)	
Current	Final
1978	—
940	1,084
2,180m x 1 4,000m x 1	→2,500m x 1 + 3,200m x 1
624	Terminal 3
287	—

Guangzhou (CAN)	
Current	Final
2004	—
—	—
3,600m x 1 3,800m x 1	3rd runway
—	Terminal 2 (320)
—	Terminal 2

Osaka (KIX)	
Current	Final
1994	—
1,055	1,300
3,500m x 1 4,000m x 1	+ 3,500m x 1
302	Terminal 2
125	—



Hong Kong (HKG)	
Current	Final
1998	2040
1,255	
3,800m x 2	—
515	890
297	1,737

Taipei (TPE)	
Current	Final
1979	2020
1,200	
3,350m x 1 3,660m x 1	—
345	Terminal 3
364	—

Bangkok (BKK)	
Current	Final
2006	—
3,200	
3,700m x 1 4,000m x 1	+ 2 runways
563	—
568	—

Manila (MNL)	
Current	Final
—	—
—	—
2,258m x 1 3,737m x 1	—
—	—
—	—

Kuala Lumpur (KUL)	
Current	Final
1998	—
3,000	10,000
4,056m x 1 4,124m x 1	+ 3 runways
384	—
123	—

Singapore (SIN)	
Current	Final
1981	—
1,663	
4,000m x 2	+ 1 runway
505	—
510	—

Jakarta (CGK)	
Current	Final
1985	—
—	—
3,600m x 1 3,660m x 1	+ 4,000m x 1
—	—
—	—

City (Airport Code)
Stage
Year of Open or Completion
Area (ha)
Number of Runways
Passenger Terminal (,000 m²)
Cargo Terminal (,000 m²)

Figure1. Outline and Development Schemes at Primary East and Southeast Asian Airports

Note: Airports with red mark opened after 1990

—means no data available.

Source: HP and Annual Reports of Individual Airports

2.2 Description of Primary East and Southeast Asian Airports from Traditional Traffic Statistics

Table 1 lists the air traffic statistics on airports worldwide in 2006. With regard to the total passengers (domestic + international), Tokyo/Haneda (top four) and Beijing (top nine) are ranked among the top ten in the world. More Asian airports are included in top ten if only international passengers are considered; Hong Kong (top five), Tokyo/Narita (top six), Singapore (top seven) and Bangkok (top nine). The same holds true for the total cargo (domestic + international). Hong Kong is listed as second, Seoul as fourth, Tokyo/Narita as fifth, Shanghai as sixth and Singapore as tenth. With respect to international cargo only, the top three are occupied by the Asian airports; Hong Kong (first), Seoul (second) and Tokyo/Narita (third). It should be noted that Seoul, after having drastically increased the volume of international cargo over years, has outnumbered Tokyo/Narita in 2006.

The airports in Asia are highly ranked among airports in the world in terms of traditional air traffic statistics in particular with respect to cargo traffic. More than half out of the top ten are occupied by the Asian airports.

Table1. Air Traffic Statistics on Airports Worldwide, 2006

1. Top 10 by Passengers

	Airport	Code	Passengers	% CHG
1	Atlanta	ATL	84,846,639	-1.2
2	Chicago	ORD	77,028,134	0.7
3	London	LHR	67,530,197	-0.6
4	Tokyo	HND	65,810,672	4.0
5	Los Angeles	LAX	61,041,066	-0.7
6	Dallas/Fort Worth	DFW	60,226,138	1.8
7	Paris	CDG	56,849,567	5.7
8	Frankkfurt	FRA	52,810,683	1.1
9	Beijing	PEK	48,654,770	18.7
10	Denver	DEN	47,325,016	9.1

2. Top 10 by International Passengers

	Airport	Code	Passengers	% CHG
1	London	LHR	61,348,340	0.6
2	Paris	CDG	51,888,936	6.2
3	Amsterdam	AMS	45,940,939	4.4
4	Frankfurt	FRA	45,697,176	1.9
5	Hong Kong	HKG	43,274,765	8.7
6	Tokyo	NRT	33,860,094	25.3
7	Singapore	SIN	33,368,099	8.6
8	London	LGW	30,016,837	4.4
9	Bangkok	BKK	29,587,773	10.3
10	Dubai	DXB	27,925,522	16.7

3. Top 10 by Cargo (metric tonnes)

	Airport	Code	Tonnes	% CHG
1	Memphis	MEM	3,692,081	2.6
2	Hong Kong	HKG	3,609,780	5.1
3	Anchorage	ANC	2,691,395	5.4
4	Seoul	ICN	2,336,572	8.7
5	Tokyo	NRT	2,280,830	-3.9
6	Shanghai	PVG	2,168,122	16.8
7	Paris	CDG	2,130,724	6.0
8	Frankfurt	FRA	2,127,646	8.4
9	Louisville	SDF	1,983,032	9.2
10	Singapore	SIN	1,931,881	4.2

4. Top 10 by International Cargo (metric tonnes)

	Airport	Code	Tonnes	% CHG
1	Hong Kong	HKG	3,578,991	5.2
2	Seoul	ICN	2,307,817	8.9
3	Tokyo	NRT	2,235,548	-3.3
4	Anchorage	ANC	2,129,796	7.8
5	Frankfurt	FRA	1,996,632	8.8
6	Singapore	SIN	1,911,214	4.2
7	Paris	CDG	1,832,283	8.6
8	Shanghai	PVG	1,829,041	14.2
9	Taipei	TPE	1,686,423	-0.4
10	Amsterdam	AMS	1,526,501	5.3

Source: Airport Council International (ACI)

3. MEASUREMENT OF NETWORK QUALITY

3.1 Three Types of Network Connectivity

The quality of an indirect connection between A and B with a transfer at hub H is not equal to the quality of a direct connection between A and B. In other words, the passenger traveling indirectly will experience additional costs due to longer travel times, consisting of detour time and transfer time. The transfer time equals at least the minimum connecting time, or the minimum time needed to transfer between two flights at hub H.

In this article, three types of connectivity are distinguished as described in Figure 2.

1. Direct Connectivity: flights between A and B without a hub transfer
2. Indirect Connectivity: flights from A to B, but with a transfer at hub X
3. Hub Connectivity: connections via (with a transfer at) hub A between origin C and destination B

The measurement of indirect connectivity is particularly important from the perspective of consumer welfare; how many direct and indirect connections are available to consumers between A and B? The concept of hub connectivity is particularly important for measuring the competitive position of airline hubs in a certain market; how does airport A perform as a hub in the market between C and B?

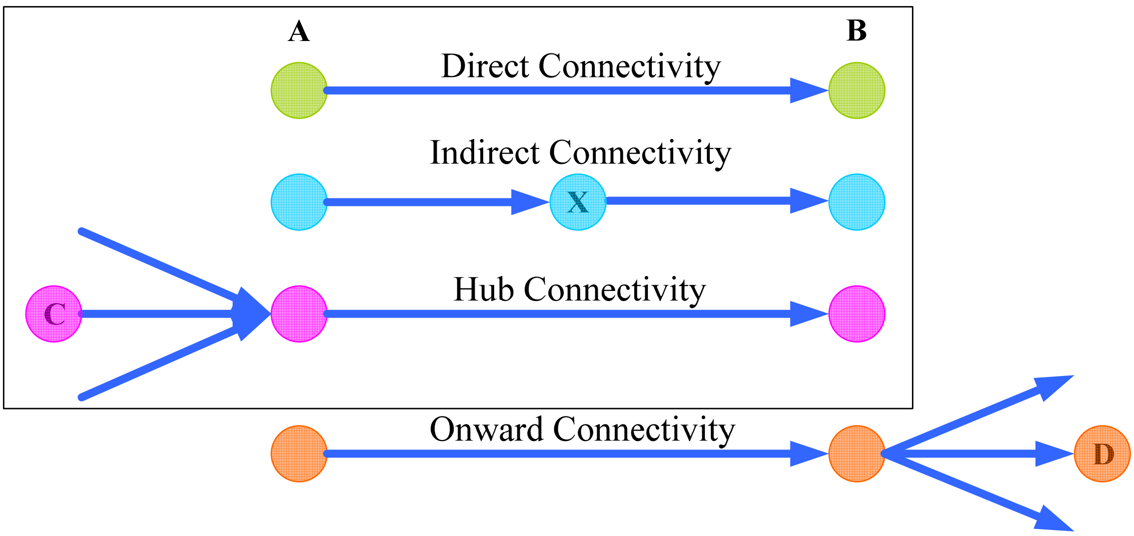


Figure2. Three Types of Connectivity

Source: SEO Economic Research

3.2 Concept of Connectivity Unit (CNU)

Many passengers make transfers at hub airports to their final destinations, even in case good direct connections are available. The choice passengers make is depending on the attractiveness of the available alternatives. Attractiveness is often expressed in utility functions, where variables like available frequencies, their travel time and fares are weighted. Other factors such as comfort, loyalty to airlines, special preferences for certain airports or airlines do also play a certain role. The latter ones are hardly systematically available and even difficult to measure, so we keep – when measuring the attractiveness of a certain alternative – the main ones: frequencies and travel time. Fares on certain routes change sometimes by the day. Advanced yield managing systems, used by some major airlines, result in large differences of fares. So a systematic and coherent fare information system, representing the actual fares paid, is neither available. However there may be some systematics in fare differentiation. Fares on non-stop or direct routes are generally higher than on indirect routes between two airports. Fares on indirect routes are generally lower for on-line (or code-shared) connections than for interline connections. Fares on a route are generally lower if more competitors are operating on these routes. And finally fares are 'carrier-specific' and are depending on the ability of carriers to compete on fares. It can be concluded that fares are generally depending on the number of competitors on the route and the product characteristics, like travel time, number of transfers, kind of connection (on-line or interline) and the carrier operating on the route. So – although we have no explicit fare information – fare differentiation is taken implicitly on board when taking the latter characteristics as a proxy.

The route characteristics mentioned are to be operationalized in a variable indicating connectivity, expressed in so called ‘connectivity units (CNU’s)’. This variable is a function of frequencies, travel time and the necessity of a transfer.

3.3 Methodology: NetScan Model

The NetScan model, developed by Veldhuis (1997) and owned by SEO Economic Research, has been applied here to quantify the quality of an indirect connection and scale it to the quality of a theoretical direct connection (Veldhuis (1997), IATA (2000)).

NetScan model assigns a quality index to every connection, ranging between 0 and 1. A direct, non-stop flight is given the maximum quality index of 1. The quality index of an indirect connection will always be lower than 1 since extra travel time is added due to transfer time and detour time of the flight. The same holds true for a direct multi-stop connection: passengers face a lower network quality because of en-route stops compared to a non-stop direct connection.

If the additional travel time of an indirect connection exceeds a certain threshold, the quality index of the connection equals 0. The threshold of a certain indirect connection between two airports depends on the travel time of a theoretical direct connection between these two airports. In other words, the longer the theoretical direct travel time between two airports, the longer the actual maximum indirect travel time can be. The travel time of a theoretical direct connection is determined by the geographical coordinates of origin and destination airport and assumptions on flight speed and time needed for take-off and landing. By taking the product of the quality index and the frequency of the connection per time unit (day, week, and year), the total number of connections or connectivity units (CNU's) can be derived. Summarizing, the following model has been applied for each individual (direct, indirect or hub) connection:

$$NST = (40 + 0.068 * \text{gcd}\, km) / 60 \tag{1}$$

$$MXT = (3 - 0.075 * NST) * NST \tag{2}$$

$$PTT = FLT + (3 - 0.075 * NST) * TRT \tag{3}$$

$$QLX = 1 - ((PTT - NST) / (MXT - NST)) \tag{4}$$

$$CNU = QLX * NOP \tag{5}$$

Where,

NST: non-stop travel time in hours
gcd km: great-circle distance in kilometers
MXT: maximum perceived travel time in hours
PTT: perceived travel time in hours
FLT: flying time in hours
TRT: transfer time in hours
QLX: quality index of a connection
CNU: number of connectivity units
NOP: number of operations

3.4 Data and Classification

The data used in this analysis are from OAG flight schedules in the third week of September in 2001, 2004 and 2007. Direct connections are directly available from the OAG database. Indirect connections have been constructed using an algorithm, which identifies for each incoming flight at an airport the number of outgoing flights that connect to it. The algorithm takes into account minimum connection time, and puts a limit on the maximum connecting time and routing factor. In our case, we assume 45 minutes, 1440 minutes, and 170 %, respectively. Next, the NetScan model assigns to each direct and indirect connection a quality index, ranging between 0 and 1.

Within the NetScan model, only online connections are considered as viable connections. In other words, the transfer between two flights has to take place between flights of the same airline or global airline alliance. For the years 2004 and 2007, three global airline alliances are distinguished: One World, Sky Team and Star Alliance. For the year 2001, an additional alliance, Wings Alliance is also distinguished, which submerged into Sky Team in 2004 (see Appendix A).

The study area is specified as East and Southeast Asia, including Japan, Korea, China, Taiwan and the five ASEAN countries. The airports, selected and analyzed in our study, are thirteen primary airports in this area described in Figure 1; two Japanese airports (Tokyo/Narita and Osaka/Kansai), one Korean airport (Seoul/Incheon), four Chinese airports (Beijing, Shanghai/Pudong, Guangzhou and Hong Kong), one Taiwanese airport (Taipei) and five

ASEAN airports (Manila, Bangkok, Kuala Lumpur, Singapore and Jakarta). The analysis considers the connectivity between these airports and airports worldwide.

4. DIRECT AND INDIRECT CONNECTIVITY: EVALUATION OF AIRPORTS FROM THE PERSPECTIVE OF CONSUMER WELFARE

4.1 Direct and Indirect Connectivity

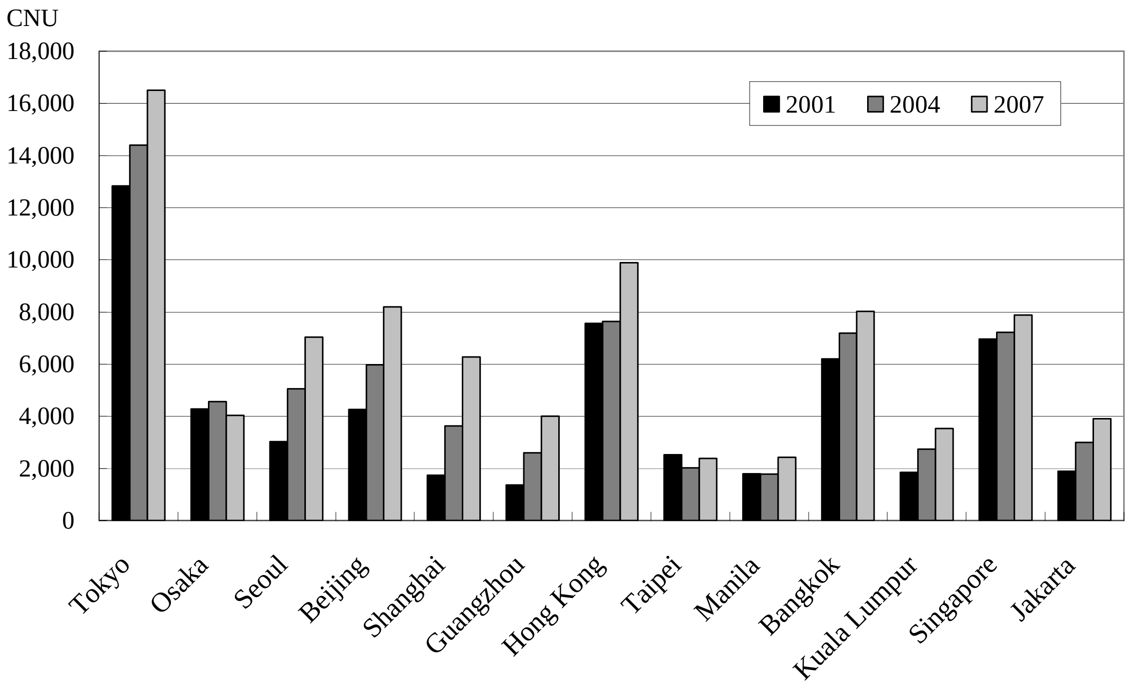


Figure3. Total Connectivity (Direct and Indirect) at Primary East and Southeast Asian Airports, 2001, 2004 and 2007

Figure 3 shows the total direct and indirect connectivity at the primary East and Southeast Asian airports in 2001, 2004 and 2007. Over these three years, the total connectivity at Tokyo was outstanding; 12,833 CNU in 2001, 14,402 CNU in 2004 and 16,506 CNU in 2007. The second largest one in 2007 was that of Hong Kong (9,883 CNU), followed by Beijing (8,203 CNU), Bangkok (8,017 CNU), Singapore (7,885 CNU) and Seoul (7,034 CNU).

Table2. Percentage Growth in Total Connectivity (Direct and Indirect) at Primary East and Southeast Asian Airports, 2001-2007

Airport	2001-2004	2004-2007	2001-2007
Tokyo	12.2	14.6	28.6
Osaka	6.7	-11.6	-5.7
Seoul	66.9	39.2	**132.3**
Beijing	39.9	37.3	**92.2**
Shanghai	**110.0**	72.6	**262.4**
Guangzhou	**90.5**	54.1	**193.4**
Hong Kong	1.0	29.4	30.7
Taipei	-20.3	17.8	-6.1
Manila	-0.7	36.3	35.3
Bangkok	15.8	11.6	29.3
Kuala Lumpur	47.7	28.9	**90.4**
Singapore	3.7	9.1	13.2
Jakarta	58.2	30.1	**105.8**

Table 2 shows the percentage growth in the total connectivity (direct and indirect) between 2001 and 2007. The highest growth percentages can be found at the two airports in Mainland China. The total connectivity at Shanghai and Guangzhou increased about 260 and 190 percent between these years, respectively. One reason behind this is that these two cities, as mentioned before, opened a new international airport in the past ten years. Seoul (+132 %), Jakarta

(+106 %), Beijing (+92 %) and Kuala Lumpur (+90 %) experienced remarkable growth levels. On the contrary, some airports, such as Osaka and Taipei, showed negative growth rates between these years. The percentage growth in total connectivity was around minus 12 percent between 2004 and 2007 and around minus 6 percent between 2001 and 2007 at Osaka. It was partly because Tokyo opened the second runway in 2002, which induced some airlines to move their flights from Osaka to Tokyo, owing to the economic recession in the Kansai Area. Taipei decreased its total connectivity around 20 percent between 2001 and 2004 and around 6 percent between 2001 and 2007, which was largely effected by the considerable reduction of direct connections to North America between 2001 and 2004. Others, such as Tokyo, Hong Kong, Bangkok and Singapore, experienced modest growth levels.

4.2 Directional Connectivity

Before analyzing the directional connectivity, the detailed region on 'Asia/Pacific' is defined as shown in Table 3. Note that Hawaii, Guam etc. are included in Oceania, not in North America in this definition.

Table3. Definition on Asia/Pacific Region

East Asia	Dem. Peop's Rep. Korea, Japan, Mongolia, P. R. China, Republic of Korea, Taiwan
Southeast Asia	Brunei Darussalam, Cambodia, Indonesia, Lao Peoples Dem. Rep., Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam
South Asia	Bangladesh, Bhutan, Dem. Rep. of Afghanistan, India, Maldives, Nepal, Pakistan, Sri Lanka
Central Asia and Russia	Kazakhstan, Kyrgyzstan, Russian Fed/Siberia, Tajikistan, Turkmenistan, Uzbekistan
Oceania	American Samoa/Mariana Isls./Guam, Australia, Cocos/Keeling Isls. Indian Ocean, Fiji, French Polynesia, Hawaii USA, Marshall Islands, Micronesia Federation, Nauru, New Caledonia, New Zealand, Niue, Pacific, Pacific Ocean, Papua New Guinea, Rep. of Kiribati, Samoa, Solomon Islands, Tonga Is. South Pacific, Tuvalu, Vanuatu, Wallis Futuna Island

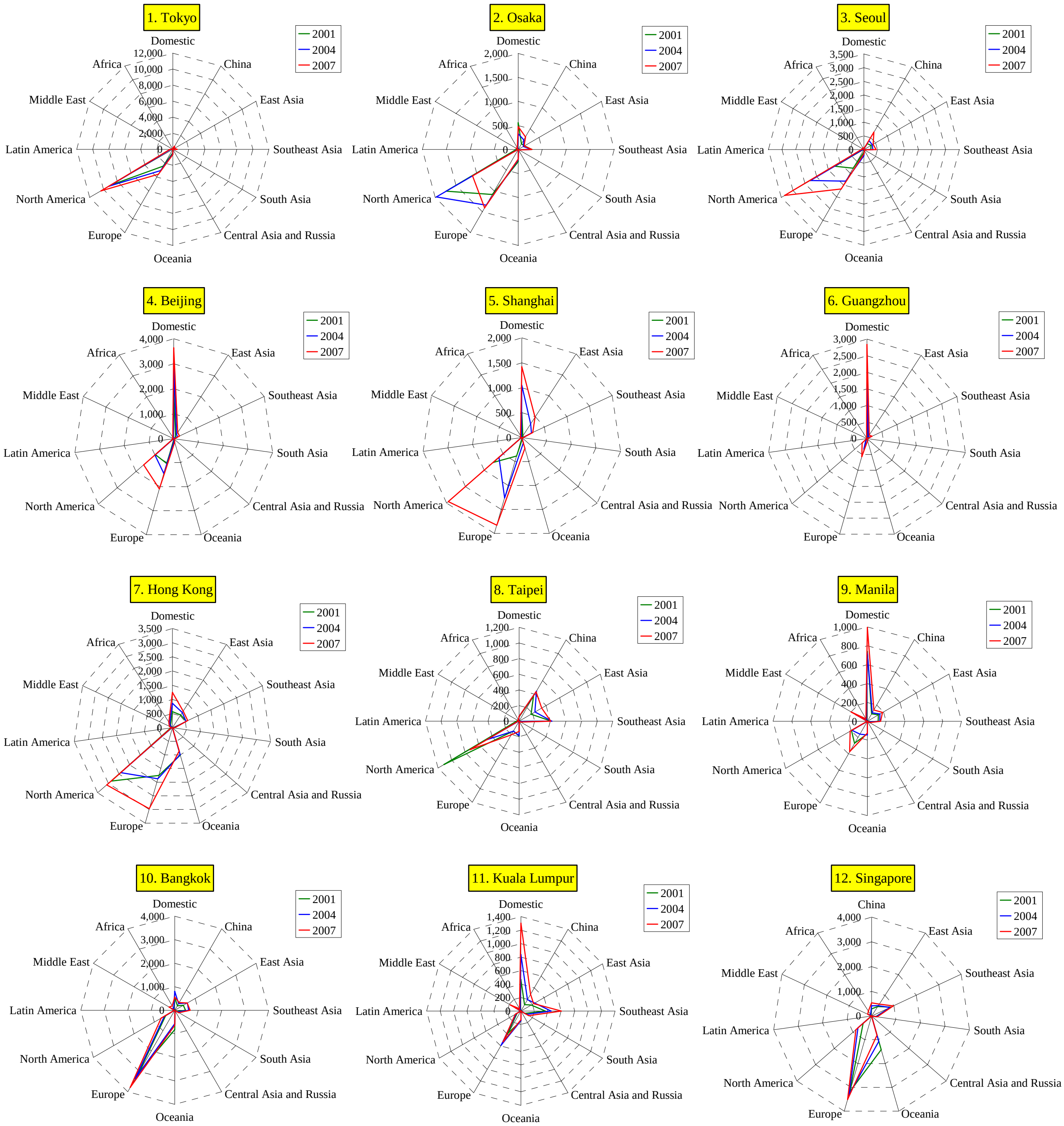
Figure 4 shows the directional total connectivity (direct and indirect) at each airport in this region in 2001, 2004 and 2007. These figures demonstrate to which market each airport is serving, that is, in which market each airport has a competitive position. The first observation on these figures is that there exist little connectivity, for almost all airports, to South Asia, Central Asia and Russia/Siberia, Latin America, Middle East and Africa.

With regard to the two Japanese airports, Tokyo has absolutely the best competitive position in the transpacific market, with relatively strong competitive edges to European destinations. In addition, it has a larger connectivity to Latin America among the airports concerned, though it has less connectivity to domestic destinations because of the split-up between Tokyo/Haneda. The connectivity from Tokyo in almost all directions increased over these years. Osaka had, on the other hand, the largest connectivity to Europe in 2007, high connectivity to North America but modest connectivity to domestic and Asian destinations. However, Osaka experienced negative growth rates over the years. Concerning Seoul, it increased its connectivity especially to North America and Europe during this period, though it has quite a little connectivity to domestic destinations because of the split-up between Seoul/Gimpo.

With respect to the four Chinese airports, Beijing and Guangzhou have absolutely a lot of domestic connectivity, whereas Shanghai shows, besides domestic connectivity, strong connectivity to North America. Hong Kong is serving, on top of domestic destinations, North America and Europe, East and Southeast Asia and Oceania. These Chinese airports demonstrate high percentage growth rates during the years analyzed. With respect to Taipei, it cancelled a lot of direct connections to North America between 2001 and 2004, with the result of reducing considerable total connectivity in this direction in this term.

As for the five ASEAN airports, the connectivity of Bangkok and Singapore are characterized by the competitive position to Europe with the modest growth rates over the years, whereas, Manila, Kuala Lumpur and Jakarta are rather oriented to the domestic or Asia-specific destinations. Kuala Lumpur and Jakarta show the high growth rates throughout the period.

In short, there is a kind of airport classification in directional connectivity; competitive airports in the market to North America (Tokyo, Seoul), to Europe (Bangkok, Singapore), to North America and Europe (Osaka, Shanghai, Hong Kong), Asia-specific (Taipei, Manila, Kuala Lumpur) and domestic-oriented (Beijing, Guangzhou and Jakarta).



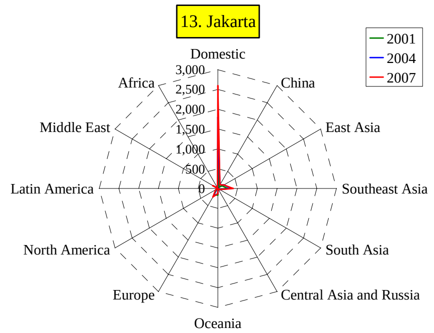


Figure4. Directional Connectivity (Direct and Indirect) at Primary East and Southeast Asian Airports, 2001, 2004 and 2007

5. HUB CONNECTIVITY: EVALUATION OF AIRPORTS FROM THE PERSPECTIVE OF HUB SITE

5.1 Hub Connectivity

Figure 5 shows the hub connectivity via (with a transfer at) the primary East and Southeast Asian airports in 2001, 2004 and 2007. In 2007, Tokyo shows the largest hub connectivity (5,042 CNU) among the airports in this region. In the second group are included Beijing (4,481 CNU), Singapore (4,291 CNU) and Bangkok (4,051 CNU), followed by the third group with Seoul (3,683 CNU), Hong Kong (3,578 CNU) and Kuala Lumpur (3,156 CNU).

There are, however, some geographical differences on hub connectivity among these airports. For example, Tokyo shows the strongest hub connectivity to North America and Seoul relatively large hub connectivity to China, East and Southeast Asia. Beijing and Jakarta, on the other hand, specialize in domestic hub connectivity. Hong Kong demonstrates strong intercontinental hub connectivity and Singapore large hub connectivity to Southeast Asia, Oceania and Europe etc.

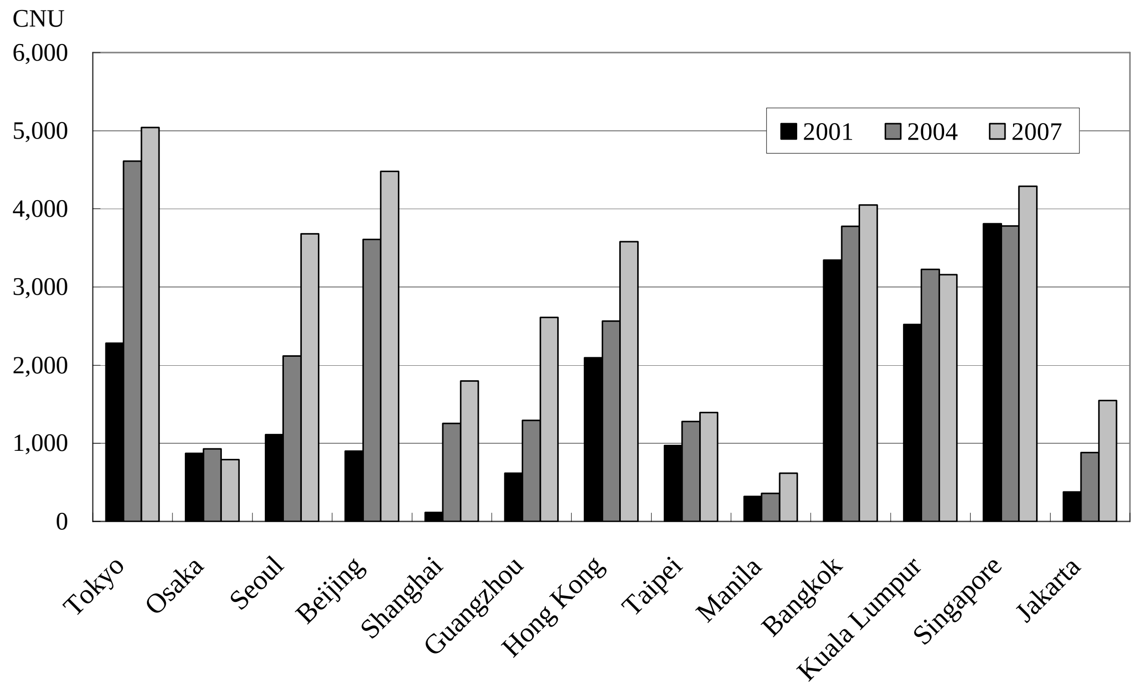


Figure5. Hub Connectivity at Primary East and Southeast Asian Airports, 2001, 2004 and 2007

As for the percentage growth in hub connectivity between 2001 and 2007, the three Chinese airports in Mainland China demonstrate high growth rates; Beijing (+397 %), Shanghai (+1,451 %) and Guangzhou (+323 %), as shown in Table 4. This means these Chinese airports are quickly developing as hubs. One should note, however, that hub connectivity levels at these airports were rather low in 2001. The hub connectivity via Jakarta and Seoul also increased drastically between these years. High growth rates at these airports except Seoul are largely attributed to that in domestic market, while Seoul increased its hub connectivity to all over the world, especially to China, East and Southeast Asia, Oceania, North American and Europe. This is because the two Korean airlines (Korean Air and Asiana Airlines) strategically develop their networks at Seoul/Incheon. As for the two Japanese airports, Tokyo experienced remarkable growth levels (+121 %), while Osaka showed negative growth percentages over these years (-9 %). It decreased its hub connectivity especially to Southeast Asia, Oceania and North America. Others, such as Hong Kong, Bangkok and Singapore, experienced modest growth levels.

Table4. Percentage Growth in Hub Connectivity at Primary East and Southeast Asian Airports, 2001-2007

Airport	2001-2004	2004-2007	2001-2007
Tokyo	**102.1**	9.3	**121.0**
Osaka	6.8	-15.0	-9.2
Seoul	90.3	73.9	**230.9**
Beijing	**300.2**	24.2	**396.8**
Shanghai	**983.1**	43.2	**1450.5**
Guangzhou	**109.4**	**102.0**	**323.0**
Hong Kong	22.2	39.7	70.7
Taipei	31.4	8.8	43.1
Manila	12.3	71.9	93.0
Bangkok	12.9	7.2	21.1
Kuala Lumpur	27.9	-2.2	25.1
Singapore	-0.7	13.5	12.7
Jakarta	**133.2**	76.1	**310.6**

5.2 Average Hub Connectivity

Average hub connectivity indicates the average number of hub connections per direct connection, which can be defined as “hub connective performance”.

Table 5 illustrates the average hub connectivity at the primary East and Southeast Asian airports in 2001, 2004 and 2007. The largest one can be found at Tokyo, which was 2.99 CNU in 2007. This means that each outgoing flight at Tokyo connects, on average, with 2.99 incoming flights, which implies Tokyo has the largest hub connective performance among the airports concerned. This kind of competitive position of airports cannot be measured by the traditional indexes like aircraft movements, number of passengers or cargo volumes. In the same year, others, such as Seoul (2.11 CNU), Kuala Lumpur (1.33 CNU) and Singapore (2.08 CNU) showed relatively high average hub connectivity. The three airports in Mainland China, on the other hand, demonstrated low average hub connectivity levels.

Table5. Average Hub Connectivity at Primary East and Southeast Asian Airports, 2001, 2004 and 2007

Airport	2001	2004	2007
Tokyo	**1.82**	**2.85**	**2.99**
Osaka	0.74	1.00	0.74
Seoul	**1.13**	**1.74**	**2.11**
Beijing	0.43	1.17	1.14
Shanghai	0.19	0.80	0.83
Guangzhou	0.51	0.71	0.95
Hong Kong	1.13	1.17	1.30
Taipei	0.89	1.05	1.07
Manila	0.28	0.31	0.40
Bangkok	1.85	1.61	1.71
Kuala Lumpur	**2.19**	**1.93**	**1.33**
Singapore	**2.12**	**2.09**	**2.08**
Jakarta	0.30	0.40	0.51

5.3 Correlation between Direct Connectivity and Hub Connectivity

Figure 6 shows the correlation between direct connectivity and hub connectivity, after transforming each value to log-form. In this figure, thirty airports are included, consisting of twenty major airports in Asia/Pacific region and ten regional airports in Japan.

It is interesting that an S-shaped relationship can be observed between them. This indicates hub connectivity increases drastically, once the number of direct connections exceeds a certain threshold. As described in IATA (2000), hub connectivity at the primary airports in Asia/Pacific region is relatively small in comparison with the major US or European airports. From the standpoint of competitive position of airports, it is suggestive that hub connectivity at the airports analyzed in this study will follow an S-shaped path in accordance with the increment of direct connectivity.

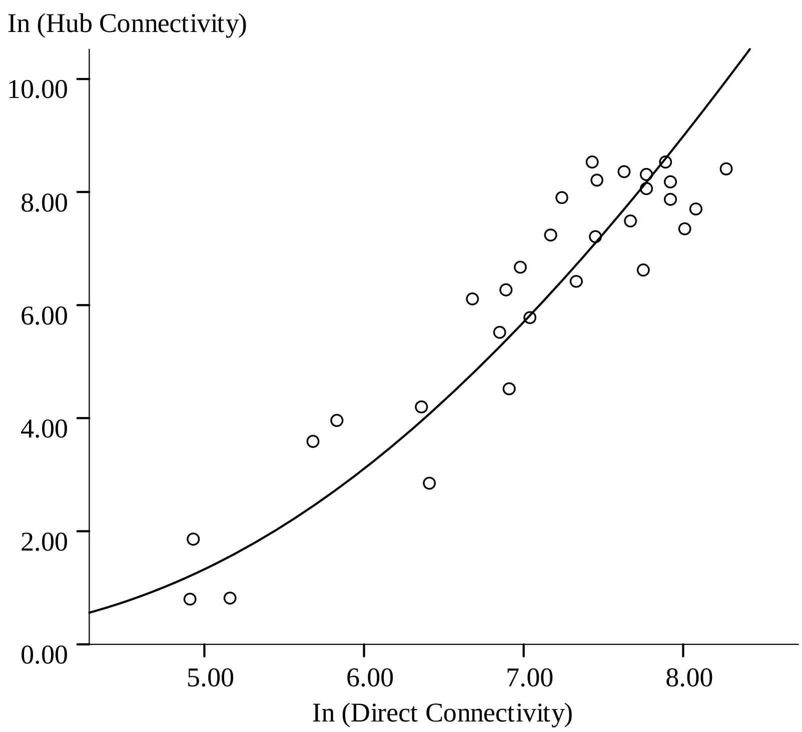


Figure6. Correlation between Direct Connectivity and Hub Connectivity, 2007

6. SUMMARY AND CONCLUSION

The growth of hub-and spoke operations has changed the competition among airlines and airports in a structural way. The competitive position of airlines and airports is usually compared in terms of aircraft movements, number of passengers or cargo volumes, as described in Section 2. Although such indicators are valuable in themselves, they do not give any information on the diversity of airline networks and the competitive position of hub airports. In this paper, the argument was put forward that the measurement of network performance in hub-and-spoke systems should take into account the quantity and quality of both direct and indirect connections.

In this paper, we measured and compared the network performance and the hub connective performance of thirteen selected primary airports in East and Southeast Asia between 2001 and 2007. We classified network connectivity into three; direct, indirect and hub to measure the network performance and applied the NetScan model, taking into account transfer time and detour time. NetScan measures the number of direct and indirect connections for each airport and weighs it for its quality in terms of transfer and detour time. All connectivity is expressed in one indicator: CNU or connectivity units.

The results revealed that Tokyo/Narita has the largest total connectivity, which is composed of direct and indirect connections. It is also the most competitive with respect to hub connectivity and average hub connectivity. The most striking growth of network developments, however, could be found at the three major airports in Mainland China; Beijing, Shanghai and Guangzhou. The number of direct, indirect and also hub connectivity at these three airports increased at a much higher rate between these years than at other airports. As for Shanghai and Guangzhou, opening of a new international airport boosted their network performance. On the contrary, others, such as Osaka and Taipei, experienced deteriorating network performance.

This analysis made here may be helpful for airlines and airports in identifying their network performance and competitive position in relation to competing counterparts. The corridor analysis, such as the competitive position of Asia/Pacific airports in the transpacific market, is left for future research.

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Appendix A. Alliance Members, 2001, 2004 and 2007

Alliance	2001	2004	2007
One World	AA AY BA CX IB LA QF EI	AA AY BA CX IB LA QF EI	AA AY BA CX IB LA QF JL MA RJ
Star Alliance	AC BD LH NH NZ OS SK SQ TG UA RG MX AN QK	AC BD JK LH LO NH NZ OS OU OZ SK SQ TG UA US KF JP RG	AC BD JK LH LO LX NH NZ OS OU OZ SA SK SQ TG TP UA US KF JP
Sky Team	AF AM AZ DL KE OK	AF AM AZ CO DL KE KL NW OK	AF AM AZ CO DL KE KL NW OK SU
Wings Alliance	CO KL NW		

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