NETWORK PERFORMANCE, HUB CONNECTIVITY POTENTIAL, AND COMPETITIVE POSITION OF PRIMARY AIRPORTS IN ASIA/PACIFIC REGION

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Abstract: Recently, hub-and-spoke network configurations are more and more developed in the Asia/Pacific region. In this paper, it is argued 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 or airlines in an integrated way. Measuring and comparing the network performance and the hub connectivity potential of selected seventeen primary airports in the Asia/Pacific region between 2001 and 2007 will be elaborated in this paper. The results revealed that Tokyo/Narita has the largest network performance and hub connectivity potential. The most striking growth of network developments can be found at Beijing, Shanghai and Guangzhou. The number of both direct and indirect/onward connectivity at these airports increased at a much higher rate between these years than at other airports. On the contrary, Sydney, Melbourne and Auckland experienced deteriorating network performance. This region also showed stronger position of One World and Star Alliance. Sky Team, however, has an innegligible position especially at Tokyo/Narita and Osaka/Kansai, in addition to Seoul/Incheon, owing to fifth and sixth freedom rights of the Sky Team members. The analysis presented in this paper may be helpful for airports or airlines in identifying their network performance and competitive position in relation to competing airports or airlines.

Key Words: Network performance; Hub connectivity potential; Competitive position of airports or airlines; NetScan Model; Connectivity Unit (CNU); Hub-and-spoke networks and Asia/Pacific region.

1. INTRODUCTION

Problems of hub location and network configuration are one of the main items that are frequently discussed. These topics draw considerable attention, particularly in the Asia/Pacific region. This region has witnessed intense competition among major airports to become key international air traffic hubs. Especially after the 1990's, new international airports started up 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), and Bangkok (2006), while Tokyo/Narita, Singapore, Taipei etc. have expanded their runways or terminals.

Airline networks in the Asia/Pacific region are progressively transforming into hub-and-spoke networks as international aviation markets become increasingly liberalized. Although restrictive bilateral air service agreements are still dominant in this region, some open-skies agreements are concluded mainly with the US. Even between the nations within this region, open-skies policy is becoming the mainstream. In addition, formation of global airline alliances is strongly putting forward these network configurations.

To date, many studies have analyzed hub-and-spoke networks. One branch of research is from the viewpoint of economic perspectives, which mainly focus on economies of density and scope (Brueckner & Spiller, 1994; Caves, Christensen & Tretheway, 1984), hub premiums (Borenstein, 1989; Oum, Zhang & Zhang, 1995), entry deterrence (Zhang, 1995), and the role of hub-and-spoke networks in airline alliances (Oum, Park & Zhang, 2000; Pels, 2001). Another branch of research is in the field of operations research, which aims spatial optimization of air networks by solving hub location problems (Kuby & Gray, 1993; O'Kelly & Miller, 1994; O'Kelly, 1998; O'Kelly & Bryan, 1998). The other branch is from the geographical approach, in which the structures, performance and spatial dimension of hub-and-spoke networks are analyzed empirically (Bania, Bauer & Zlatoper, 1998; Burghouwt, Hakfoort & Ritsema-Van Eck, 2003; Ivy, 1993; Shaw, 1993). Burghouwt and de Wit (2005), Dennis (1994) and Reynolds-Feighan (2001) explicitly underline the temporal dimension or schedule structure as an essential element for the empirical study of the structure, performance and development of hub-and-spoke networks.

These studies, however, have taken up international air traffic flows just from the standpoint of demand aspect, not capturing air network structures, schedule coordination and the resulting hub performance from the supply-aspect. Consequently, some studies have included the level of schedule coordination in the measurement of the performance and structure of hub-and-spoke networks. Veldhuis (1997) first introduced this idea and 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 the Asia/Pacific region by measuring and comparing the performance of airline networks and hub connectivity potential of selected seventeen primary airports in this region between 2001 and 2007. After classifying network connectivity into four items -direct, indirect, onward and hub connectivity, this paper introduces a single variable (Connectivity Unit; CNU) and applies a model (NetScan Model), taking into account transfer time and detour time to compute the number of connectivity units. By quantifying an indirect connection and scaling it into a theoretical direct connection, the network diversity behind direct connections and the competitive position of airports is identified. The quality and frequency of indirect connections do contribute as well to the competitive position of airports.

2. MEASUREMENT OF NETWORK QUALITY

2.1 Four Types of Network Connectivity

Here in this article, four types of connectivity are distinguished as described in Figure 1.

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. Onward Connectivity: connections via (with a transfer at) hub B between origin A and all destinations beyond hub B
4. Hub Connectivity: connections via (with a transfer at) hub A between origin C and destination B

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.

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.

Figure 1
Four Types of Connectivity

2.2 Concept of Connectivity Unit (CNU)

Many passengers transfer 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 such as available frequencies, their travel time and fares are weighted. Other factors like 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 also not available. However there may be some systematic characteristics in fare differentiation. Fares on non-stop or direct routes are generally higher than fares 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.

2.3 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 assigns a quality index to every individual 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 for the passenger. The same holds true for a direct multi-stop connection: passenger 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 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 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 (CNUs) can be derived. Summarizing the following model has been applied for each individual (direct, indirect or hub) connection:

$$MAXT = (3 - 0.075 * NST) * NST \quad (1)$$

$$PTT = FLY + (3 * TRF) \quad (2)$$

$$QUAL = 1 - ((PTT - NST) / (MAXT - NST)) \quad (3)$$

$$CNU = QUAL * FREQ \quad (4)$$

Where,

MAXT: maximum perceived travel time

NST: non-stop travel time

PTT: perceived travel time

FLY: flying time

TRF: transfer time

QUAL: quality index of an individual connection

CNU: number of connectivity units

2.4 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, NetScan 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.

The study area is specified as the Asia/Pacific region, which includes East Asia, Southeast Asia, South and West Asia, Central Asia and Russia/Siberia and Oceania. The airports, selected and analyzed in our study, are seventeen major airports in this area; 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), five ASEAN airports (Manila, Bangkok, Kuala Lumpur, Singapore and Jakarta), one Indian airport (Mumbai), and three Oceanian airports (Sydney, Melbourne and Auckland). The analysis considers the connectivity between or via these airports and airports worldwide.

3. COMPARISON OF NETWORK PERFORMANCE AND HUB CONNECTIVITY POTENTIAL AMONG PRIMARY AIRPOTS IN ASIA/PACIFIC REGION

3.1 Total Network Connectivity

Figure 2 shows the total connectivity by direct, indirect/onward and hub at the primary Asia/Pacific airports in 2007. As for direct connectivity, Chinese airports had definitely many direct connections; Beijing (3,918 CNU), Hong Kong (2,745 CNU), Guangzhou (2,743 CNU) and Shanghai (2,152 CNU), most of which were domestic ones at the three airports in Mainland China. Jakarta was the second largest airport in this region with regard to direct connectivity, which accommodated 3,025 direct flights in this year. In addition to them, Sydney, Kuala Lumpur, Bangkok, Mumbai and Singapore had more than 2,000 direct frequencies. On the other hand, the remarkably largest indirect/onward connectivity was found at Tokyo, which was 14,821 CNU in 2007, followed by Hong Kong (7,138 CNU), Singapore (5,820 CNU), Bangkok (5,650 CNU), Seoul (5,288 CNU), Beijing (4,285 CNU) and Shanghai (4,117 CNU). With respect to hub connectivity, Sydney and Tokyo were in the first tier, with 5,066 CNU and 5,042 CNU, respectively. Beijing (4,481 CNU), Singapore (4,291 CNU), Bangkok (4,051 CNU), Seoul (3,683 CNU), Hong Kong (3,578 CNU) and Kuala Lumpur (3,156 CNU) were in the second tier.

Figure 2
Total Network Connectivity at Primary Asia/Pacific Airports, 2007

Table 1 shows the percentage growth in these types of connectivity between 2001 and 2007. The highest growth percentages can be found, through all types of connectivity, at the three airports in Mainland China. In particular, the total number of hub connectivity at Shanghai increased about 1,450 percent, and that of indirect/onward connectivity at Guangzhou increased about 690 percent between these years. One reason behind this is that these two cities, as mentioned before, opened a new international airport in 1999 and in 2004, respectively. Seoul (+231 %), Jakarta (+311 %) and Mumbai (+208 %) experienced remarkable growth levels, especially in terms of hub connectivity. In addition, Tokyo demonstrated rather high percentage growth (+121 %) over hub connectivity. On the contrary, some airports showed negative growth rates, such as Osaka and the three Oceanian airports; Sydney, Melbourne, and Auckland. Osaka decreased its direct connectivity around 22 percent between 2001 and 2004, and indirect/onward and hub connectivity around 19 percent and 15 percent between 2004 and 2007, respectively. The two Australian airports experienced the highest negative growth percentages. It was because Ansett Australia ceased all operations in 2002 as a consequence of its bankruptcy. Others, such as Hong Kong, Bangkok and Singapore, experienced modest growth levels over all types of connectivity.

Table 1
Percentage Growth in Direct, Indirect/Onward and Hub Connectivity at Primary Asia/Pacific Airports, 2001-2007

3.2 Total Network Size

The total network size, an indication of the total non-stop travel hours flown from an airport, is obtained by the sum of multiplying each connectivity level with its distance in non-stop travel time. This index becomes larger if an airport is serving a lot of long-haul intercontinental destinations. In this sense, this is indicative of competitive position among airports from the standpoint of network diversity or intercontinental hub site.

Figure 3 shows the total network size by direct, indirect/onward and hub connectivity at the primary Asia/Pacific airports in 2007. Through almost all types of connectivity, Tokyo was the largest, with slightly behind Beijing in that of direct connectivity. It demonstrated 11,059, 175,680 and 62,986 hours weekly in the total network size by direct, indirect/onward and hub network, respectively. This is because Tokyo is serving mainly international destinations and the share of North American or European routes at this airport is relatively high. It will be positioned as a gateway airport in the transpacific market, reflecting the high level of total hub network size.

At most of the airports, the total indirect/onward network size was the largest, such as Seoul (61,031 hours weekly), Hong Kong (86,449 hours weekly), Bangkok (60,873 hours weekly) and Singapore (68,135 hours weekly), all of which, at the same time, demonstrated the high levels of total hub network size. Beijing (40,711 hours weekly) and Sydney (42,782 hours weekly) comparatively had the large hub network size.

Figure 3
Total Network Size at Primary Asia/Pacific Airports, 2007

Over the years, similar changes can be observed as the percentage growth in CNU shown in Table 1. Figure 4 shows the percentage growth in the total network size between 2001 and 2007. The highest growth percentages were found at the three airports in Mainland China. For example, the total indirect/onward network size at Guangzhou increased about 1,200 percent, and the total hub network size at Shanghai increased about 1,600 percent between these years. In most cases, the total hub network size experienced the high levels of growth, including Seoul (+231 %), Beijing (+481 %), Guangzhou (+344 %), Jakarta (+216 %) and Mumbai (+513 %). On the contrary, some airports, such as Osaka, Taipei, Sydney, Melbourne and Auckland, demonstrated negative growth rates. Among them, the two Australian airports decreased largely the total hub network size by around 40 percent, and Osaka experienced the negative growth percentages over all types of connectivity. Others, such as Tokyo, Hong Kong, Bangkok and Singapore, showed modest growth levels for all types of connectivity.

Figure 4

Percentage Growth in Total Network Size by Direct, Indirect/Onward and Hub Connectivity at Primary Asia/Pacific Airports, 2001-2007

3.3 Onward Connectivity Ratio and Hub Connectivity Ratio

The onward connectivity ratio indicates the average number of onward connections beyond another hub per direct connection. The hub connectivity ratio, on the other hand, means the average number of hub connections via the hub per direct connection. The former can be defined as ‘onward connectivity potential’, and the latter as ‘hub connectivity potential’.

Table 2 illustrates the ratios of both connectivity at the primary Asia/Pacific airports in 2001, 2004 and 2007. The largest one can be found at Tokyo both in onward and hub connectivity ratios, which were 8.79 CNU 2.99 CNU in 2007, respectively. In other words, each direct flight from Tokyo generated on average 8.79 connection beyond (with a transfer at) another hub and 2.99 connection via (with a transfer at) Tokyo. This implies that Tokyo has the largest onward and hub connectivity potential in this region. 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 Osaka (2.75 CNU), Seoul (3.03 CNU), Hong Kong (2.60 CNU), Bangkok (2.39 CNU) and Singapore (2.82 CNU) showed relatively high onward connectivity ratio, and Seoul (2.11 CNU), Kuala Lumpur (1.33 CNU), Singapore (2.08 CNU), Sydney (1.89 CNU) and Auckland (1.95 CNU) demonstrated a comparatively high hub connectivity ratio. The three airports in Mainland China, on the other hand, showed the low levels in this measurement.

Table 2
Onward Connectivity Ratio and Hub Connectivity Ratio at Primary Asia/Pacific Airports, 2001, 2004 and 2007

4. EFFECTS OF AIRLINE ALLIANCES ON NETWORK PERFORMANCE AND HUB CONNECTIVITY POTENTIAL

4.1 Network Connectivity by Alliances

The shares of each global airline alliance for direct, indirect/onward and hub connectivity at the primary Asia/Pacific airports in 2007 are described in Figure 5. As for direct connectivity, non-alliance carriers are the largest players in this region. Their shares are remarkably high especially at the three airports in Mainland China, Taipei, Manila, Kuala Lumpur, Jakarta and Mumbai. This is a symptom of the emergence of regional carriers or low-cost carriers in this region.

Other airports are roughly classified into three alliance groups; One World (Hong Kong, Sydney and Melbourne), Star Alliance (Bangkok, Singapore and Auckland), One World & Star Alliance (Tokyo and Osaka) and Star Alliance & Sky Team (Seoul). This rough classification much better clarifies hub connectivity by alliances. This is because the share of each alliance group at an airport depends on the alliance the home based airline belongs to. For example, One World accounts for 88.0 % of hub connectivity at Hong Kong the home base of Cathay Pacific Airways, 87.5 % at Sydney and 70.6 % at Melbourne the home bases of Qantas Airways. Star Alliance shows the percentage of 94.6 % at Bangkok with Thai Airways International, 90.8 % at Singapore with Singapore Airlines and 95.0 % at Auckland with Air New Zealand. With regard to Tokyo and Osaka, Japan Airlines, which joined One World in 2007, and All Nippon Airways, which is a member of Star Alliance, have high shares, the latter being the largest operator at these two airports. As for Seoul, Korean Air, which is one of the founders of Sky Team, and Asiana Airlines, which belongs to Star Alliance, are the predominant carriers for hub connectivity.

Besides, it is remarkable that Sky Team accounts for quite a large share of hub connectivity especially at Tokyo owing to the fifth freedom rights of US airlines out of Tokyo. Northwest Airlines, one of its members, operates a substantial number of beyond rights. It is also interesting that the shares of Sky Team for indirect/onward connectivity at these two Japanese airports are quite high, though there does not exist a Sky Team member in Japan. This reflects the network performance and diversity of Sky Team members, including the typical example of Korean Air through Seoul. Another example can be found in the share of One World for hub connectivity at Singapore. Qantas Airways operates a hub at Singapore based on seventh freedom rights, as well as British Airways.

Note that Air China and Shanghai Airlines joined Star Alliance in December, 2007, whereas, others, such as China Eastern Airlines, China Southern Airlines or Malaysia Airlines System, are expected to join one of the global airline alliances in the future. These future alliance members will drastically change the balance among the three incumbent alliances.

Figure 5
Shares of Alliances for Direct, Indirect/Onward and Hub Connectivity at Primary Asia/Pacific Airports, 2007

4.2 Changing Share Levels of Alliances

Table 3 shows the changes in shares of each global airline alliance for direct, indirect/onward and hub connectivity at the primary Asia/Pacific airports between 2001 and 2007. Two "composition effects" are reflected in these changes; one is the effect of joining or leaving an alliance and the other is the effect of the network strategy by an airline. The former effects can be found at the two Japanese airports, one Korean airport and two Australian airports. At Tokyo and Osaka, the share of One World drastically increased from 2001 to 2007, because Japan Airlines joined One World in 2007. At Seoul, Star Alliance took over the second position, replacing non-alliance carriers, with the membership of Asiana Airlines in Star Alliance in 2003. The shares of Star Alliance, on the contrary, largely decreased at Sydney and Melbourne between 2001 and 2007, where Ansett Australia, a former member of this Alliance, ceased all operations in 2002. The latter effects can be observed, for instance, at the two Japanese airports. Sky Team increased its share between these years for indirect/onward connectivity at Tokyo and Osaka, and for hub connectivity at Tokyo. As mentioned above, Sky Team members, such as Korean Air or Northwest Airlines, coordinate their flight schedule between the incoming flights from/to Japan and the outgoing flights from/to their own airport, like Seoul or Los Angeles, boosting its share for indirect/onward connectivity at the two Japanese airports. The increase in the share of Sky Team for hub connectivity at Tokyo was 18.9 % (from 3.1 % in 2001 to 22.0 % in 2007), as a result of the beyond rights by Northwest Airlines.

Table 3
Changes in Shares of Alliances for Direct, Indirect/Onward and Hub Connectivity at Primary Asia/Pacific Airports, 2001-2007

Table 4 summarizes the percentage share of alliances by network connectivity at the primary Asia/Pacific airports in 2001, 2004 and 2007. This clearly describes the rise in the share of Sky Team and non-alliance members over this period, mainly because of the integration of Wings Alliance into Sky Team in 2004 and the recent upsurge of regional carriers and low-cost carriers.

Table 4

Percentage Share of Alliances by Network Connectivity at Primary Asia/Pacific Airports, 2001, 2004 and 2007

Note: Calculated from the sum of the seventeen Asia/Pacific primary airports.

5. 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 has been usually compared in terms of aircraft movements, number of passengers or cargo volumes. 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, it was argued 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.

This paper measures and compares the network performance and the hub connectivity potential of selected seventeen primary airports in the Asia/Pacific region between 2001 and 2007. After classifying network connectivity into four items -direct, indirect, onward and hub connectivity, this paper introduced a single variable (Connectivity Unit; CNU) and applied a model (NetScan Model), taking into account transfer time and detour time to compute the number of connectivity units. By quantifying an indirect connection and scaling it into a theoretical direct connection, the network diversity behind direct connections and the competitive position of airports was identified. The quality and frequency of indirect connections do contribute as well to the competitive position of airports.

The results revealed that Tokyo has the largest network performance and hub connectivity potential with respect to the total network size, indirect/onward connectivity and hub connectivity ratio. The most striking growth of network developments can be found at the three major airports in Mainland China; Beijing, Shanghai and Guangzhou. The number of both direct and indirect/onward connectivity at these 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, the three Oceanian airports; Sydney, Melbourne and Auckland experienced deteriorating network performance because of the bankruptcy of Ansett Australia. This region also showed stronger position of One World and Star Alliance because there are relatively many carriers in the region belonging to these airline alliances. Sky Team's position, however, is innegligible at the two Japanese airports, Tokyo and Osaka, in addition to Seoul, owing to fifth and sixth freedom rights of the Sky Team members.

The analysis presented in this paper may be helpful for airports or airlines in identifying their network performance and competitive position in relation to competing airports or airlines.

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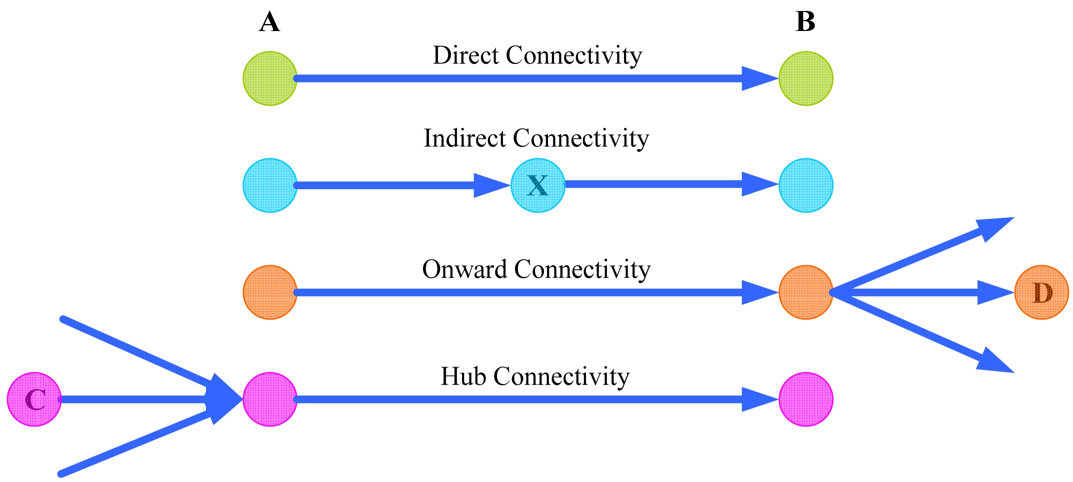


Figure1. Four Types of Connectivity

Source: SEO Economic Research

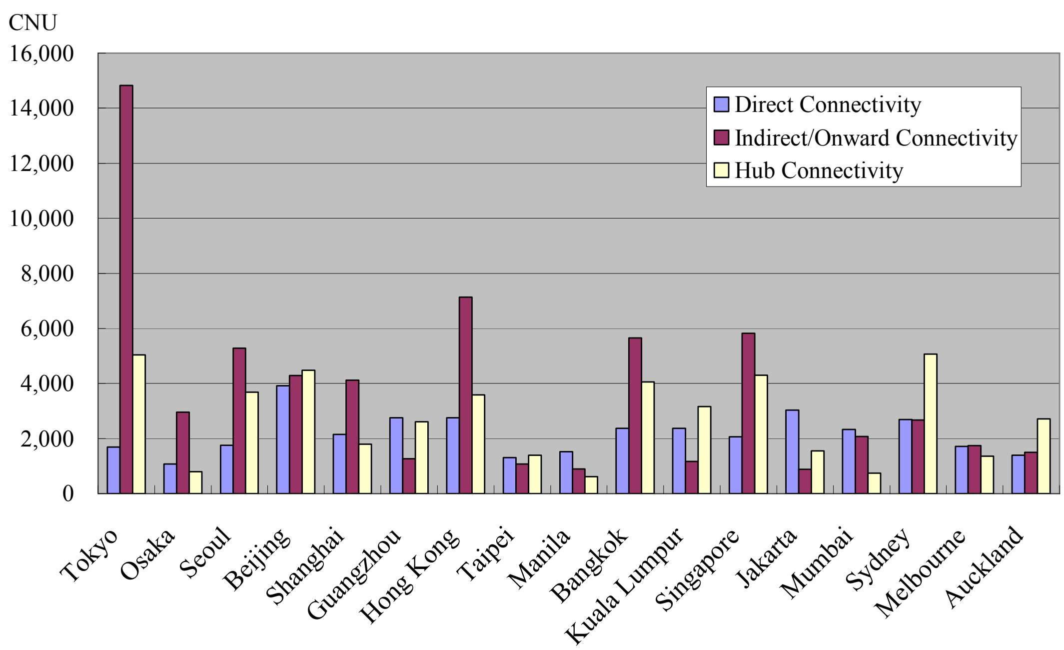


Figure2. Total Network Connectivity at Primary Asia/Pacific Airports, 2007

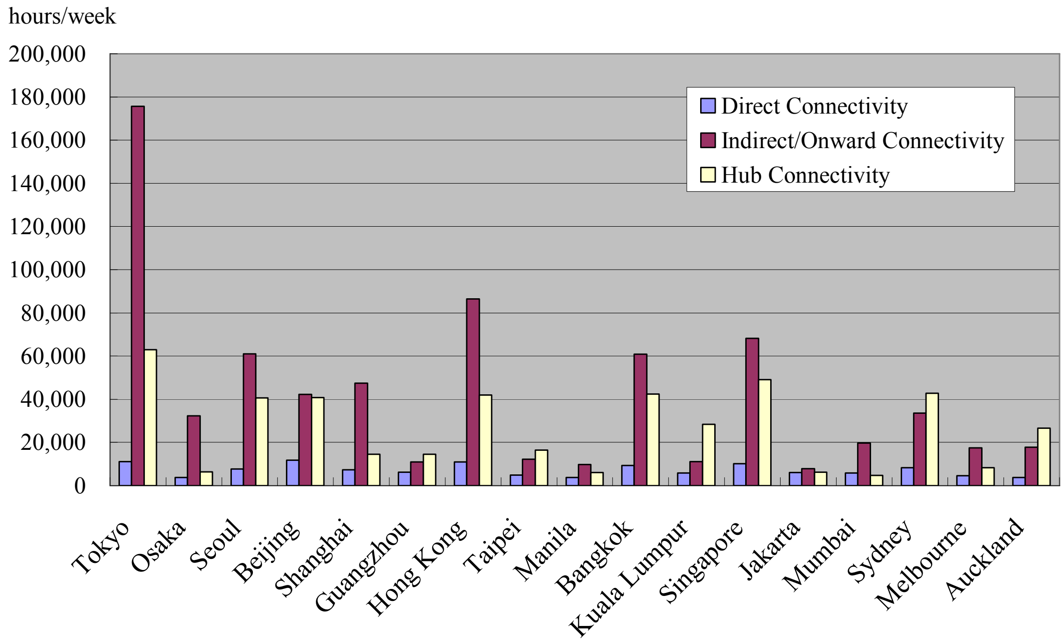


Figure3. Total Network Size at Primary Asia/Pacific Airports, 2007

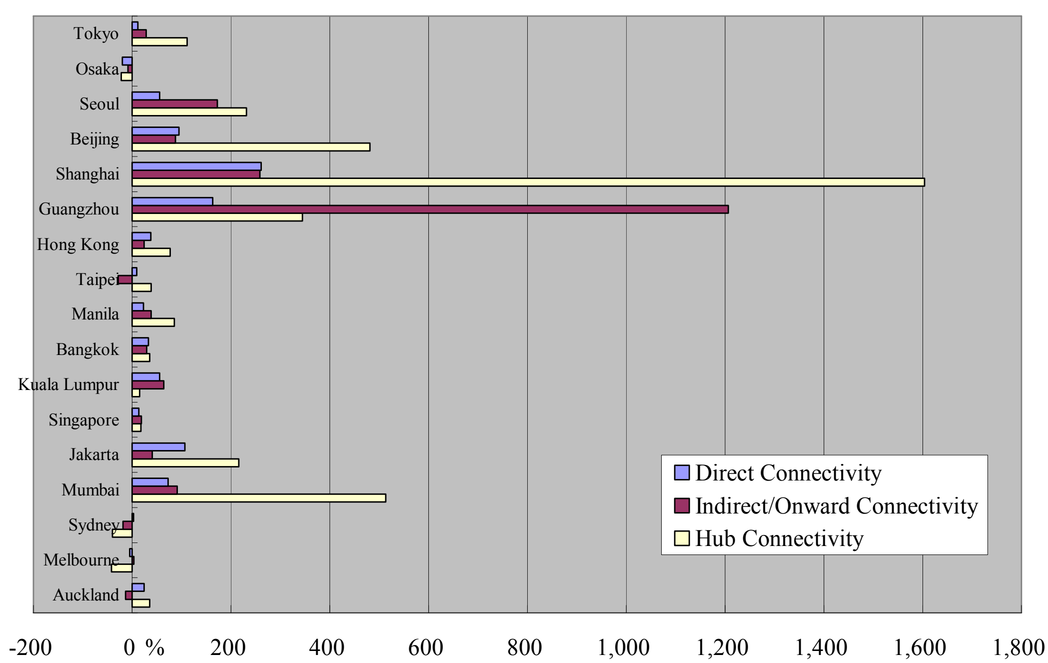
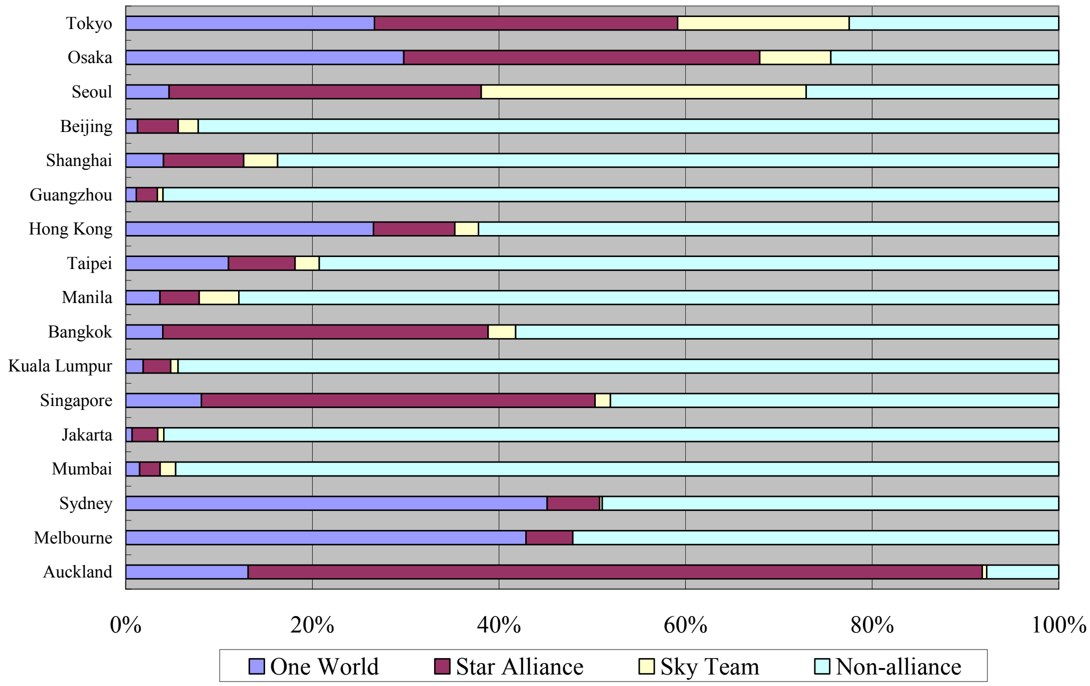
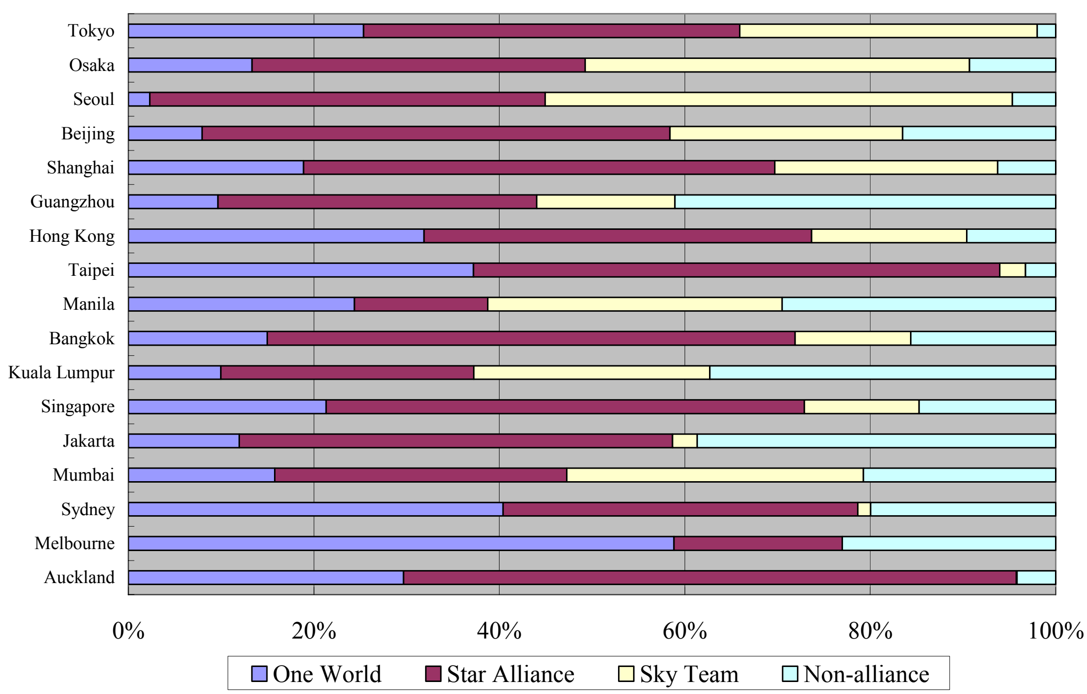


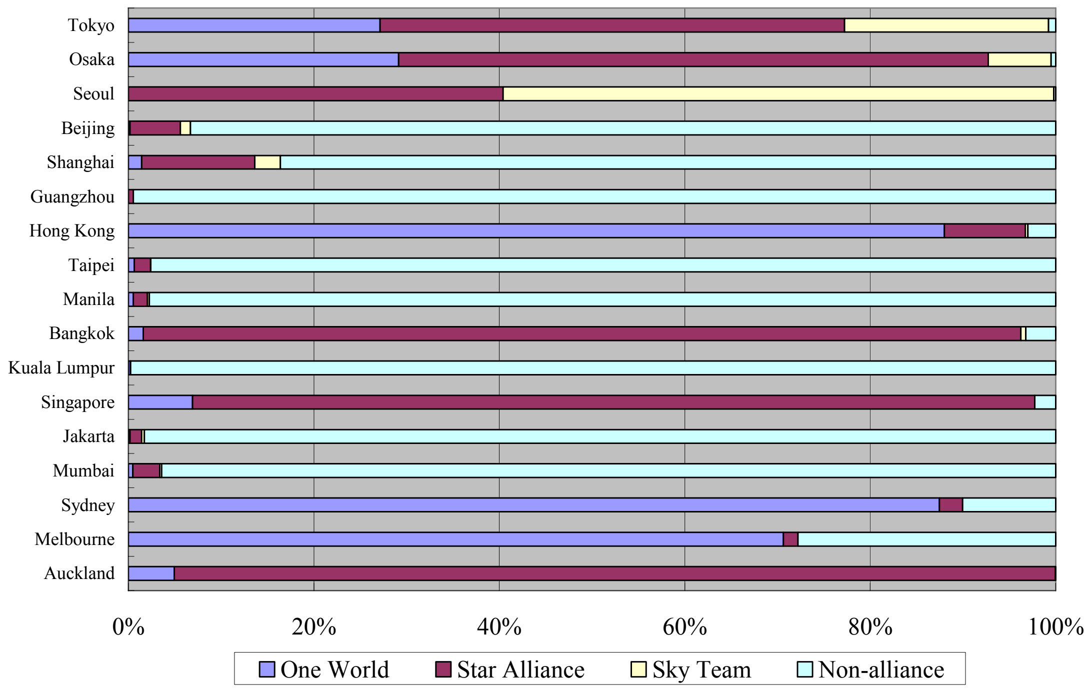
Figure4. Percentage Growth in Total Network Size by Direct, Indirect/Onward and Hub Connectivity at Primary Asia/Pacific Airports, 2001-2007



1. Direct Connectivity



2. Indirect/Onward Connectivity



3. Hub Connectivity

Figure5. Shares of Alliances for Direct, Indirect/Onward and Hub Connectivity at Primary Asia/Pacific Airports, 2007

Table1. Percentage Growth in Direct, Indirect/Onward and Hub Connectivity at Primary Asia/Pacific Airports, 2001-2007

Airport	Direct			Indirect / Onward			Hub		
	2001-2004	2004-2007	2001-2007	2001-2004	2004-2007	2001-2007	2001-2004	2004-2007	2001-2007
Tokyo	29.0	4.2	34.3	10.4	15.9	28.0	**102.1**	9.3	**121.0**
Osaka	▲ 21.6	16.0	▲ 9.1	17.5	▲ 18.6	▲ 4.4	6.8	▲ 15.0	▲ 9.2
Seoul	23.8	43.1	77.2	87.7	37.9	**158.9**	90.3	73.9	**230.9**
Beijing	49.0	26.6	88.7	31.3	48.8	95.5	**300.2**	24.2	**396.8**
Shanghai	**161.3**	37.6	**259.6**	82.9	99.0	**263.9**	**983.1**	43.2	**1450.5**
Guangzhou	51.2	50.4	**127.5**	**385.5**	62.6	**689.3**	**109.4**	**102.0**	**323.0**
Hong Kong	17.4	25.7	47.5	▲ 4.3	30.9	25.2	22.2	39.7	70.7
Taipei	11.9	6.7	19.4	▲ 44.5	34.8	▲ 25.3	31.4	8.8	43.1
Manila	0.9	30.9	32.1	▲ 3.5	46.3	41.1	12.3	71.9	93.0
Bangkok	29.7	0.8	30.7	10.1	16.8	28.7	12.9	7.2	21.1
Kuala Lumpur	45.3	41.6	**105.7**	51.8	8.8	65.2	27.9	▲ 2.2	25.1
Singapore	0.8	14.1	15.0	4.7	7.4	12.5	▲ 0.7	13.5	12.7
Jakarta	73.3	37.0	**137.5**	27.4	10.8	41.2	**133.2**	76.1	**310.6**
Mumbai	12.9	53.6	73.5	32.9	34.0	78.1	47.1	**109.6**	**208.4**
Sydney	▲ 10.9	2.6	▲ 8.6	▲ 26.3	9.8	▲ 19.2	▲ 45.1	7.6	▲ 40.9
Melbourne	▲ 10.9	▲ 0.7	▲ 11.5	▲ 9.6	4.2	▲ 5.8	▲ 28.5	▲ 20.2	▲ 42.9
Auckland	14.7	▲ 1.5	13.0	▲ 17.2	1.0	▲ 16.4	40.2	▲ 5.1	33.0

Table2. Onward Connectivity Ratio and Hub Connectivity Ratio at Primary Asia/Pacific Airports, 2001, 2004 and 2007

Airport	Onward Connectivity Ratio			Hub Connectivity Ratio		
	2001	2004	2007	2001	2004	2007
Tokyo	**9.23**	**7.90**	**8.79**	1.82	**2.85**	**2.99**
Osaka	**2.61**	**3.92**	**2.75**	0.74	1.00	0.74
Seoul	**2.07**	**3.14**	**3.03**	1.13	1.74	**2.11**
Beijing	1.06	0.93	1.09	0.43	1.17	1.14
Shanghai	1.89	1.32	1.91	0.19	0.80	0.83
Guangzhou	0.13	0.43	0.46	0.51	0.71	0.95
Hong Kong	**3.06**	**2.50**	**2.60**	1.13	1.17	1.30
Taipei	1.32	0.66	0.83	0.89	1.05	1.07
Manila	0.55	0.53	0.59	0.28	0.31	0.40
Bangkok	**2.42**	**2.06**	**2.39**	1.85	1.61	1.71
Kuala Lumpur	0.61	0.64	0.49	**2.19**	1.93	1.33
Singapore	**2.88**	**2.99**	**2.82**	**2.12**	**2.09**	**2.08**
Jakarta	0.49	0.36	0.29	0.30	0.40	0.51
Mumbai	0.87	1.02	0.89	0.18	0.24	0.32
Sydney	1.13	0.93	1.00	**2.92**	1.80	1.89
Melbourne	0.95	0.97	1.01	1.22	0.98	0.79
Auckland	1.46	1.05	1.08	1.65	**2.02**	1.95

Table3. Changes in Shares of Alliances for Direct, Indirect/Onward and Hub Connectivity at Primary Asia/Pacific Airports, 2001-2007

Airport	Connectivity	One World	Star Alliance	Sky Team	Wings Alliance	Non-alliance
Tokyo	Direct	**17.0%**	4.6%	11.0%	-16.0%	-16.7%
	Indirect/Onward	11.4%	-8.6%	**19.7%**	-21.5%	-1.0%
	Hub	**25.0%**	12.8%	**18.9%**	-21.8%	-34.9%
Osaka	Direct	**26.3%**	8.8%	4.0%	-6.1%	-33.1%
	Indirect/Onward	-5.2%	-3.7%	**29.4%**	-22.2%	1.8%
	Hub	**28.4%**	6.7%	5.8%	-5.9%	-34.9%
Seoul	Direct	1.4%	**18.3%**	1.5%	-2.2%	-19.0%
	Indirect/Onward	-1.2%	-8.8%	17.8%	-7.2%	-0.6%
	Hub	0.0%	**33.6%**	-1.8%	-0.3%	-31.4%
Beijing	Direct	0.9%	0.6%	1.2%	-0.8%	-1.9%
	Indirect/Onward	2.2%	2.5%	11.6%	-13.8%	-2.6%
	Hub	0.2%	1.4%	0.8%	0.0%	-2.4%
Shanghai	Direct	4.0%	1.4%	3.1%	-2.4%	-6.1%
	Indirect/Onward	18.9%	-11.2%	14.5%	-21.7%	-0.4%
	Hub	1.4%	10.2%	2.8%	0.0%	-14.3%
Guangzhou	Direct	1.1%	1.3%	0.6%	0.0%	-3.1%
	Indirect/Onward	9.7%	10.0%	14.9%	0.0%	-34.6%
	Hub	0.0%	0.5%	0.0%	0.0%	-0.5%
Hong Kong	Direct	-4.0%	-4.2%	0.9%	-1.6%	8.9%
	Indirect/Onward	4.3%	-5.0%	10.3%	-8.2%	-1.5%
	Hub	4.6%	-4.8%	0.2%	0.0%	0.1%
Taipei	Direct	-3.2%	-2.6%	2.6%	-2.9%	6.2%
	Indirect/Onward	10.8%	-9.0%	2.8%	-2.9%	-1.7%
	Hub	-4.3%	-3.7%	0.0%	0.0%	8.0%
Manila	Direct	-0.4%	-0.2%	3.4%	-5.5%	2.6%
	Indirect/Onward	-3.6%	-4.2%	8.9%	-8.7%	7.6%
	Hub	-1.3%	0.0%	0.2%	-1.0%	2.1%
Bangkok	Direct	-2.4%	**-20.4%**	1.3%	-2.2%	**23.7%**
	Indirect/Onward	-8.1%	9.7%	5.0%	-7.7%	1.1%
	Hub	-1.1%	-2.3%	0.5%	-0.1%	3.0%
Kuala Lumpur	Direct	-0.6%	-4.8%	0.6%	-1.1%	5.9%
	Indirect/Onward	-0.6%	**-20.1%**	**24.9%**	-26.3%	22.1%
	Hub	0.2%	0.0%	0.0%	0.0%	-0.2%
Singapore	Direct	-3.7%	-5.7%	0.7%	-1.7%	10.3%
	Indirect/Onward	-5.4%	0.9%	6.2%	-5.0%	3.3%
	Hub	-2.3%	1.3%	0.0%	0.0%	1.1%
Jakarta	Direct	-1.7%	-3.3%	-0.6%	-1.0%	6.6%
	Indirect/Onward	-9.5%	-3.7%	1.0%	0.0%	12.3%
	Hub	-0.7%	1.3%	0.3%	0.0%	-0.9%
Mumbai	Direct	-0.9%	0.9%	-0.3%	-0.9%	1.1%
	Indirect/Onward	3.5%	13.0%	16.4%	-18.2%	-14.8%
	Hub	-0.4%	2.1%	0.0%	0.0%	-1.6%
Sydney	Direct	-3.3%	**-36.5%**	0.1%	0.0%	**39.7%**
	Indirect/Onward	4.0%	**-20.7%**	1.2%	0.0%	15.5%
	Hub	**28.6%**	**-38.4%**	0.0%	0.0%	9.8%
Melbourne	Direct	-0.7%	**-42.0%**	0.0%	0.0%	**42.7%**
	Indirect/Onward	4.8%	**-21.8%**	0.0%	0.0%	16.9%
	Hub	15.6%	**-42.8%**	0.0%	0.0%	27.3%
Auckland	Direct	-1.9%	-0.5%	-0.2%	0.0%	2.6%
	Indirect/Onward	6.9%	-7.8%	-0.2%	0.0%	1.1%
	Hub	-0.6%	0.5%	0.0%	0.0%	0.1%

Table4. Percentage Share of Alliances by Network Connectivity at Primary Asia/Pacific Airports, 2001, 2004 and 2007

Alliance	Direct Connectivity			Indirect/Onward Connectivity			Hub Connectivity		
	2001	2004	2007	2001	2004	2007	2001	2004	2007
One World	15.4%	11.9%	12.1%	21.0%	19.3%	21.5%	26.9%	21.2%	22.8%
Star Alliance	26.3%	17.9%	15.2%	49.1%	43.6%	43.7%	45.9%	36.2%	33.8%
Sky Team	**2.5%**	**4.2%**	**4.2%**	**9.0%**	**25.2%**	**23.4%**	**2.4%**	**6.2%**	**7.4%**
Wings Alliance	2.2%	0.0%	0.0%	11.6%	0.0%	0.0%	1.7%	0.0%	0.0%
Non-alliance	**53.5%**	**66.0%**	**68.6%**	**9.3%**	**11.9%**	**11.4%**	**23.1%**	**36.4%**	**36.0%**
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Note: Calculated from the sum of the seventeen Asia/Pacific primary airports.