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EFFECTS OF NEW AIRPORTS ON HUB-NESS OF CITIES: A CASE OF OSAKA

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Abstract: This paper examines the 'hub-ness' of Asian major cities in terms of international air traffic flows and analyzes the effects of new airports on the hub-ness of cities. After evaluating the international air network structures in Asia for 1982, 1990 and 2000, the degrees of hub-ness for prospective seven major cities in Asia from 1982 to 2000 are clarified by a basic gravity model composed of GDP, population and distance introducing 'city-dummy variables'. The effects of Kansai International Airport (KIX) on the hub-ness of Osaka are also examined by panel data analysis introducing 'new airport-dummy variable'. The results reveal that Tokyo, Hong Kong and Singapore are strengthening their positions as international air transportation hubs in this region. From the temporal analysis, the hub-ness of Hong Kong and Seoul is remarkably on the rise. On top of these cities, Osaka is having larger and larger hub-ness in virtue of KIX.

Key Words: International air networks, Hub-ness, Gravity model, Panel data analysis, Asian region, Kansai International Airport (KIX)

1. INTRODUCTION

1.1 Backgrounds of this Paper

Much attention has been paid to the relationships among international cities according to the borderless economy. For example, Tokyo, London and New York are called as 'world cities' with an influx of foreign enterprises and an accumulation of headquarters and R&D divisions (Freedmann, 1986; Machimura, 1994; Keeling, 1995). At the same time, new international urban systems are now forming in accordance with regional integration such as EU and NAFTA (Fujita; 1996). Especially, the present urban hierarchies are being modified in EU where people and goods are freely going and coming as a result of tariff removal and currency unification. On the other hand, hub location problems have drawn considerable attention, particularly in Europe and Asia, which encompass many countries. These regions have also witnessed intense competition among major cities to become a hub site for international transportation.

Many factors influence the formation of new urban systems. In this paper, the focus is on the role of international air traffic flows. Airports and aviation make an important contribution to local, state or regional economies. The location of an airport influences the geographic distribution of industries and can be a significant factor in the decisions of certain industries, e.g., high-tech ones, to be located in a specific state or region. A large hub airport serving many destinations with frequent flights has the potential of exerting a major impact on adjacent urban areas. What impacts airports have in the change of urban systems, in other words, whether or not it is necessary for cities to have a large hub airport so as to be ranked first, second, or third in urban hierarchies is an intriguing issue. As we see, especially in the Asia region, some national governments recognize the importance of airports and have responded by opening a new large airport; Osaka in 1994, Macao in 1995, Kuaka Lumpur in 1998, Hong Kong in 1998, Shanghai in 1999, Seoul in 2001, Guangzhou in 2004 and Nagoya in 2005. In addition, Bangkok is now building a new international airport with Tokyo, Singapore and Taipei etc. expanding their current runways or terminal buildings. There have occurred strong competitions for a hub site among major cities in Asia. The basic idea under this is that cities with a large hub airport will get the significant priority. Another interesting issue is what kind of factors enable an airport to become a large hub. Among them will perhaps be the number of destinations and flights, which is strongly influenced by strategies of airlines or airport authorities, policies adopted by national governments, geographical advantages, population of urban agglomeration, the number of headquarters of multinational firms, volumes of industrial outputs and so on.

1.2 Purpose and Outline of this Paper

This paper is intended to analyze the current international air network structures in the context of relationships or connectivity across major cities in Asia, to reveal the hub-ness of Asian major cities and to examine the effects of new airports on the hub-ness of cities. In the next section, the international air network structures in Asia for 1982, 1990 and 2000 are detailed. In the third section, after briefly reviewing the previous studies on air traffic flows, the model used here is specified and the results of analysis are discussed. In this section, the degrees of hub-ness for prospective seven major cities in Asia, namely Tokyo, Osaka, Seoul, Taipei, Hong Kong, Bangkok and Singapore, are revealed by a basic gravity model composed of GDP, population and distance introducing city-dummy variables. The effects of Kansai International Airport (KIX) on the hub-ness of Osaka are, at the same time, examined by panel data analysis introducing new airport-dummy variable in the forth section. A summary of the findings is presented in the final section.

1.3 Data used in this Paper

Before undertaking the analysis, it is necessary to offer the definition of regions analyzed here, data sources used in this paper etc.. First, the Asian region analyzed in this paper is interpreted as East Asia, Southeast Asia, South Asia, West Asia up to Pakistan, Central Asia and Oceania as defined by the Airports Council International (ACI). This ACI definition reflects relatively well the economic relationships among nations. Second, the data used here are displayed in Table 1. Since those on international air traffic flows between cities from International Civil Aviation Organization (ICAO) are available only from 1982 in standard format, the analysis in this paper applies to this period. The data on GDP per capita, taken mainly from International Monetary Fund (IMF), are adjusted in US dollars at the constant 1990 prices. The purchasing parity index is applied to some countries such as those in the former Soviet Union, because these countries have experienced high inflation. Concerning population data, the concept of urban agglomeration, rather than that of city proper, is mainly applied since urban agglomeration better reflects the population of hinterlands of airports. Third, to reflect air traffic volume, workload unit (WLU) is used here, which is a traffic measure combining passengers and cargoes. A WLU is equivalent to one terminal passenger or a hundred kilograms of cargo handled (Doganis; 1992, p.20). The cities and city-pairs discussed below are those, as of 2000, having airport traffic volume exceeding five million WLU and those, as of each year, having air traffic flows exceeding three hundred thousand WLU, respectively. Lastly, cities are the basic unit of analysis in this paper, so airport numbers are aggregated when cities have multiple airports.

Table 1. Data Sources

Data	Sources
Volume of International Air Passenger and Cargo Flows between Cities	International Civil Aviation Organization. (1982-2000) On-Flight Origin and Destination. ICAO, Montreal.
Volume of International Air Passengers and Cargoes handled at Airports	International Civil Aviation Organization. (1982, 1990, 2000) Airport Traffic. ICAO, Montreal.
	Airports Council International. (2000) Worldwide Airport Traffic Report. ACI, Vienna.
Distance between Cities	International Civil Aviation Organization. (1982-2000) Traffic by Flight Stage. ICAO, Montreal.
Real GDP per Capita	International Monetary Fund. (2000) International Financial Statistics Yearbook. IMF, Washington.
Population of Urban Agglomeration	United Nations. (1996) World Urbanization Prospects. U.N., New York.
	United Nations. (1997) Demographic Yearbook. U.N., New York.

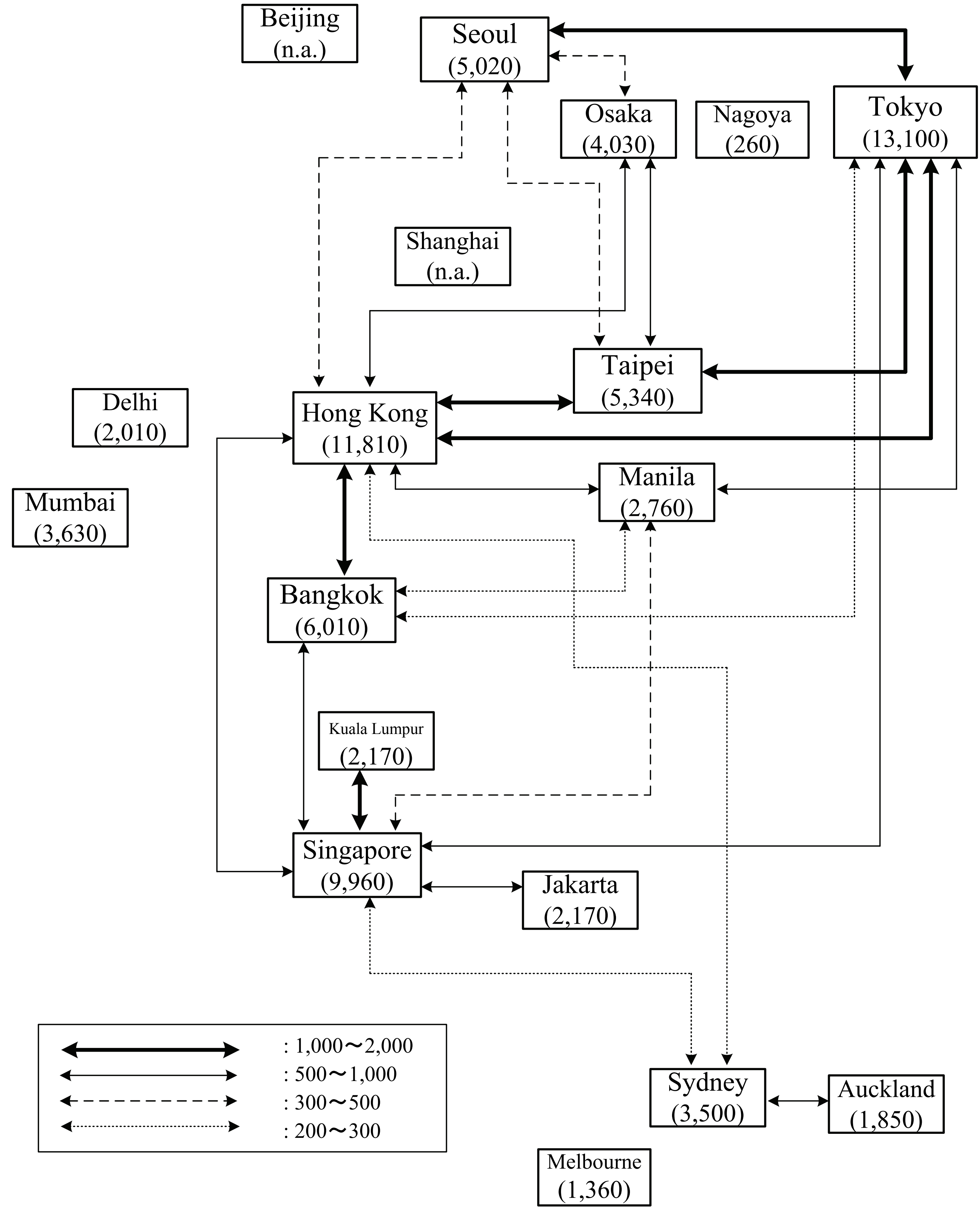
2. INTERNATIONAL URBAN SYSTEMS IN TERMS OF AIR TRAFFIC FLOWS

2.1 Previous Studies on International Urban Systems

Studies on urban systems have mainly been done from the standpoint of an accumulation of headquarters and branch offices of firms, flows of population or local traffic, and industrial structures. These studies, however, tend to be limited to intra-country or intra-region analysis and only a few ones considered international urban systems. Some researchers have analyzed international urban systems from the viewpoint of international air traffic flows, including world-wide urban systems (Keeling, 1995; Rimmer, 1996), urban systems dealing with the U. S. and Canada (Murayama, 1991a; Murayama, 1991b), and Asian urban systems focusing in particular on Japan and Korea (Park , 1995). These studies, though, have not fully delineated the overall international urban systems in a detailed fashion. Park (1995) defined the Asia region only to East Asia, Southeast Asia and South Asia. On the other hand, the patterns of international air passenger and cargo flows in Asia were analyzed in Matsumoto (2003) and those world-wide in Matsumoto (2004) in terms of international urban systems. In this section, the international air network structures in Asia are examined in terms of international urban systems as the extension of Matsumoto (2003) and (2004).

2.2 International Air Network Structures in Asia

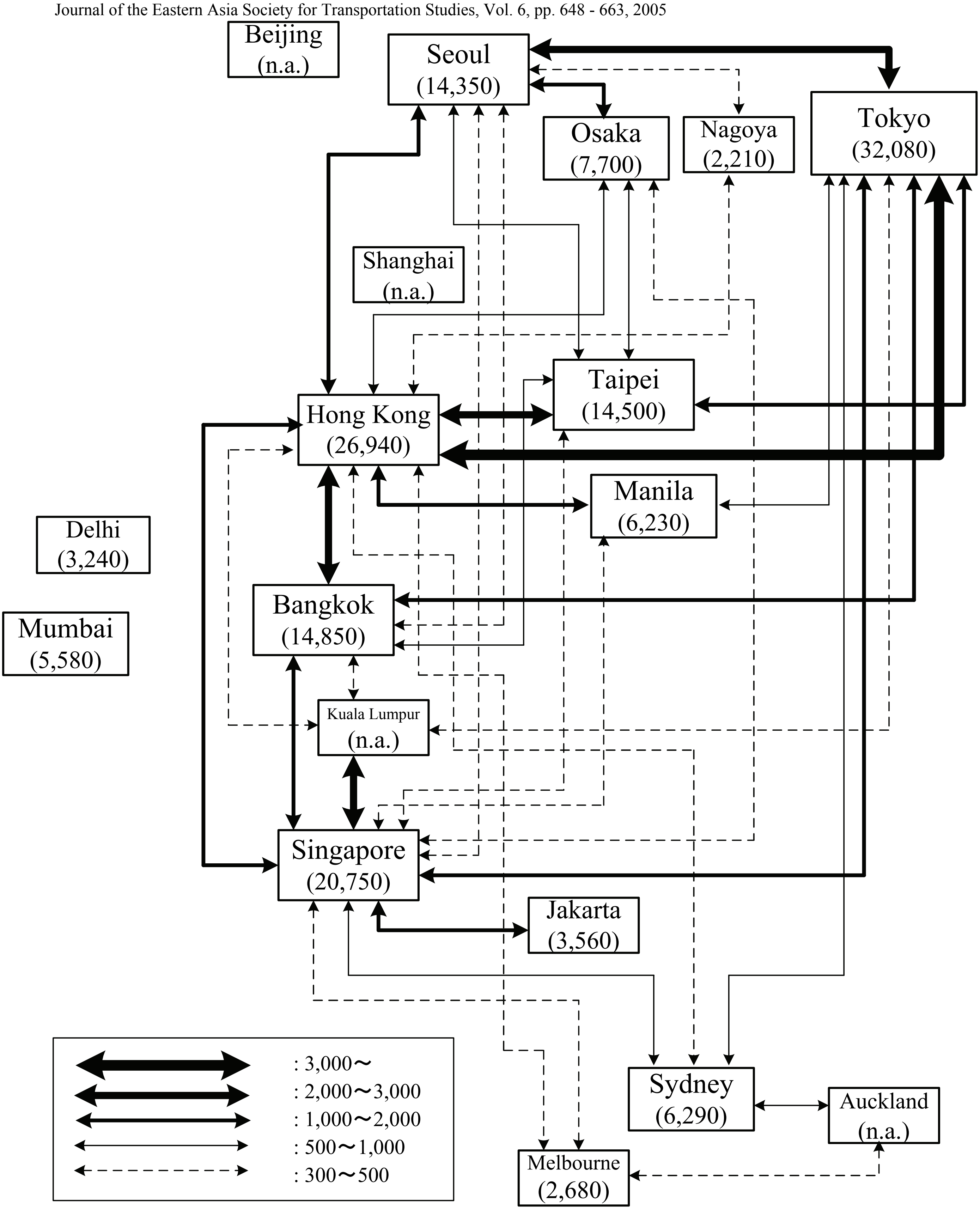
Figures 1, 2 and 3 show the international air network structures in Asia for 1982, 1990 and 2000, respectively. Concerning the international airport traffic volume in 2000, Hong Kong was the largest with 55 million WLU, which consisted of 32 million passengers and 2.3 million tons of cargo. The second largest was Tokyo with 45 million WLU (25 million passengers and 2.0 million tons of cargo), followed by Singapore with 44 million WLU (27 million passengers and 1.7 million tons of cargo). It can be said that the international air passengers and cargoes in this region flow mainly through these highest-ranked cities. Next, Seoul (34 million WLU), Bangkok (29 million WLU) and Taipei (29 million WLU) were ranked in the second tier, followed by Osaka (21 million WLU),



Notes: Unit is WLU in thousands.
n.a. indicates a lack of data.
Sources: Compiled by author from ICAO, On-Flight Origin and Destination 1982, Traffic by Flight Stage 1982 and Airport Traffic 1982.

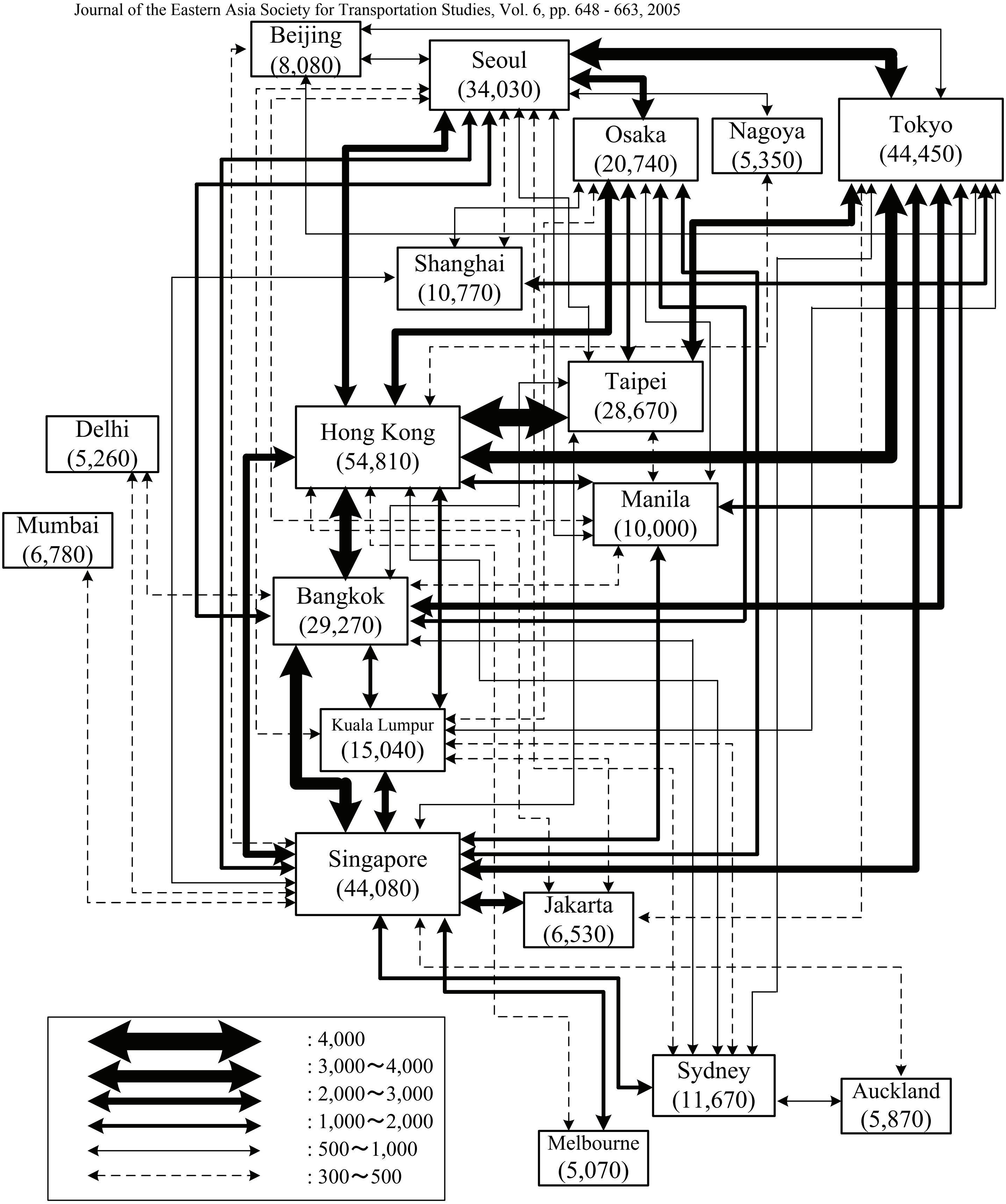
Figure 1. International Air Network Structures in 1982

Journal of the Eastern Asia Society for Transportation Studies, Vol. 6, pp. 648 - 663, 2005



Notes: Unit is WLU in thousands.
n.a. indicates a lack of data.
Sources: Compiled by author from ICAO, On-Flight Origin and Destination 1990, Traffic by Flight Stage 1990 and Airport Traffic 1990.

Figure 2. International Air Network Structures in 1990



Note: Unit is WLU in thousands.

Sources: Compiled by author from ICAO, On-Flight Origin and Destination 2000, Traffic by Flight Stage 2000 and Airport Traffic 2000 and ACI, Worldwide Airport Traffic Report 2000.

Figure 3. International Air Network Structures in 2000

Kuala Lumpur (15 million WLU) and Sydney (12 million WLU) in the third tier. As for the international air passenger and cargo flows between cities in 2000, Hong Kong-Taipei (4.0 million WLU) was first ranked, followed by Tokyo-Hong Kong (3.8 million WLU), Tokyo-Seoul (3.7 million WLU), Hong Kong-Bangkok (3.0 million WLU) and Bangkok-Singapore (3.0 million WLU). Between two and three million WLU, there were nine city-pairs including Hong Kong-Singapore and between one and two million WLU level were fourteen city-pairs. Thus, the international air networks in Asia can be judged to be very dense.

Over the years, Tokyo, Hong Kong and Singapore have been strengthening their positions in international aviation in this region. In particular, Hong Kong underwent a dramatic increase in the amount of passengers and cargoes handled, reflecting having China as its hinterland. At the same time, air networks are becoming increasingly dense despite the strong negative impact of the 1997 Asian financial crisis. In 1982, there were no air networks with over two million WLU and only six city-pairs with over one million WLU, but by 2000, cities in this region were densely connected with one another, including Chinese and Indian cities such as Beijing, Shanghai, Delhi and Mumbai.

By the way, China is now rapidly growing in the world economy and plays a more and more vital role in the Asian aviation. To do a rigorous analysis on the hub-ness in Asia, it will be indispensable to take into account the air traffic flows between Hong Kong and Shanghai as well as those between Hong Kong and Beijing.

3. AN ANALYSIS OF HUB-NESS OF ASIAN MAJOR CITIES IN TERMS OF INTERNATIONAL AIR TRAFFIC FLOWS

3.1 Previous Studies on Air Traffic Flows

To date, a number of studies have been conducted in the fields of economic geography and regional science to determine the spatial orders or rules of air passenger and cargo flows. Initially, Taaffe (1962) attempted to apply the gravity model to air passenger flows in the U.S. from the viewpoint of spatial organization. Econometric methods were also introduced into the analysis of network flows. They were, at first, simple gravity models using the variables of population and distance to predict the number of passengers (Harvey, 1951; Richmond, 1955) and were later improved to the modified gravity models embracing other variables such as income, education level, accumulation level of enterprises and dummy variables representing the peculiar indexes of cities such as location advantages and climate (Lansing, J.B. *et al*., 1958; Lansing, J.B. *et al*., 1961). There have also been studies based on multi-regression analysis focusing on the supply side by introducing fare, time and service frequencies (Howrey, 1969), and with a gravity model applied separately to business passengers, tourist passengers and cargoes (Long, 1970).

3.2 Model Specifications

Following these traditional studies on air traffic flows, the equation estimated here is a gravity model that aims at revealing the hub-ness of cities. The specifications of the model are made separately for passengers and for cargoes. Here, the explained variables are net international air passenger or cargo flows. The explanatory variables are GDP, population of urban agglomeration and distance. In addition, in order to examine the hub-ness of cities, 'city-dummy variables' are introduced for cities with, as of 2000, annual international airport traffic volume handled of more than twenty million WLU. 'e' raised to the power of the coefficients of dummy variables indicates how many times cities having over twenty million WLU generate and absorb international air passengers or cargoes explained by the basic gravity model composed of GDP, population and distance. In this analysis, these values are interpreted as the hub-ness of cities. To be more specific, the hub-ness of cities is defined, in this analysis, as the spillover of international air traffic flows explained by the basic factors; GDP, population of urban agglomeration and distance. Of course, other factors having influential impacts on the hub-ness of cities, e.g., strategies of airlines or airport authorities, policies adopted by national governments, geographical advantages, will never be negligible. However, it will not be feasible to collect all of these data on every city concerned other than those of these three factors.

That is,

$$V_{ij} = A\frac{(G_iG_j)^{\alpha}(P_iP_j)^{\beta}e^{\delta D_1}e^{\varepsilon D_2}e^{\zeta D_3}e^{\eta D_4}e^{\theta D_5}e^{\iota D_6}e^{\kappa D_7}}{(R_{ij})^{\gamma}} \tag{1}$$

Here,

V_{ij}: Volume of net international air passengers over ten thousand or volume of net international air cargoes over one hundred tons between city$_i$ and city$_j$ in 2000

G_i: Real GDP per capita in 2000 of the country of city$_i$ expressed in US dollars at the exchange rate of 2000 at the constant 1990 prices

G_j: Real GDP per capita in 2000 of the country of city$_j$ expressed in US dollars at the exchange rate of 2000 at the constant 1990 prices

P_i: Population of city$_i$ in 2000 in thousands

P_j: Population of city$_j$ in 2000 in thousands

R_{ij}: Distance between city$_i$ and city$_j$ in kilometers

D: City-dummy variables (D_1: Tokyo, D_2: Osaka, D_3: Seoul, D_4: Taipei, D_5: Hong Kong, D_6: Bangkok, D_7: Singapore)

A: Constant

Transforming equation (1) to log-form,

$$\begin{aligned}\ln V_{ij} &= \ln A + \alpha \ln G_iG_j + \beta \ln P_iP_j + \delta D_1 + \varepsilon D_2 + \zeta D_3 \\ &+ \eta D_4 + \theta D_5 + \iota D_6 + \kappa D_7 - \gamma \ln R_{ij}\end{aligned} \tag{2}$$

3.3 Results and Interpretation

After applying ordinary least squares regression analysis to equation (2), the results were interpreted focusing mainly on the city-dummy variables.

Table 2. Regression Coefficients in 2000

		Passenger	Cargo
Constant	lnA	10.40	1.51
		(10.11)	(1.03)
GDP	α	0.13	0.14
		(3.58**)	(2.85**)
Population	β	0.17	0.36
		(3.81**)	(5.81**)
Distance	γ	0.50	0.25
		(6.14**)	(2.21*)
Tokyo	δ	0.79 [2.21]	0.89 [2.44]
		(2.72**)	(2.28*)
Osaka	ε	0.13 [1.14]	0.57 [1.76]
		(0.49)	(1.61)
Seoul	ζ	0.60 [1.83]	0.93 [2.55]
		(2.41*)	(2.76**)
Taipei	η	0.52 [1.68]	0.88 [2.42]
		(1.82)	(2.30*)
Hong Kong	θ	0.86 [2.36]	1.49 [4.46]
		(3.80**)	(4.93**)
Bangkok	ι	0.92 [2.51]	1.05 [2.86]
		(4.80**)	(4.10**)
Singapore	κ	0.95 [2.58]	1.41 [4.08]
		(5.08**)	(5.58**)
Adj.R^2		0.68	0.79
D.F.		203	201

Notes: Figures in parentheses are t-values;
** and * indicate significant at the 1% and 5% levels, respectively.
Figures in [ ] are e raised to the power of the coefficients of dummy variables.

Table 2 shows the results on each estimated value of parameters. Adjusted R^2 is relatively high enough to show the fitness of this model. Judging from the t-values, the estimated values of parameters are significant at the 1% or 5% level except for those of Osaka and Taipei for passenger, and that of Osaka for cargo. It can be said that this model explains most of the international air traffic flows in Asia.

Regarding the explanatory variables, the estimated values of the GDP parameter, α, for both passenger and cargo are relatively small. This expresses GDP's lessening importance in explaining air traffic flows. The estimated value of parameter for the population variable, β, in the cargo model is about twice that for passenger. This may partly reflect the vertical division of labor in high-tech industries among developed and developing countries as well as among developing countries. For example, intermediate goods in such industries are produced in countries that are abundant in cheaper labor. On the other hand, the estimated value of parameter for distance, γ, is more than twice as large for passenger as for cargo, indicating the greater sensitivity of passengers to journey length. Statistics involving the raising of 'e' by the dummy variable coefficients partly reveal the hub-ness of Tokyo, Hong Kong, Singapore and also Bangkok for passenger. The results for cargo, in particular, reflect the hub-ness of Hong Kong, the hinterland of which is China, and that of Singapore which functions as the transshipment base in Asia.

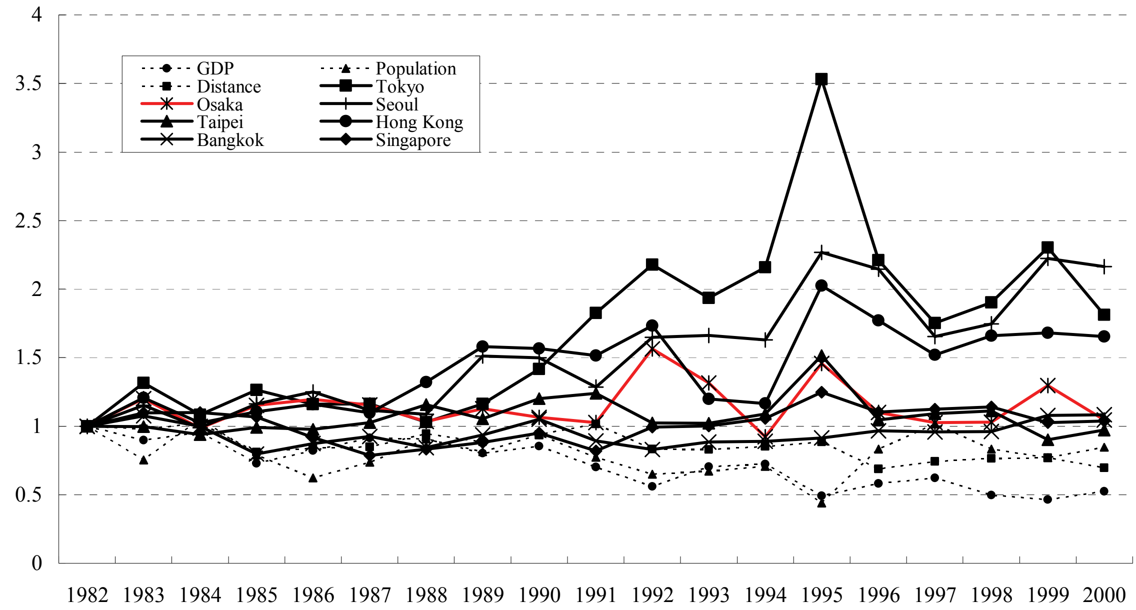


Figure 4. Time-Series Changes on Each Estimated Value of Parameters from 1982 to 2000
(Passenger)

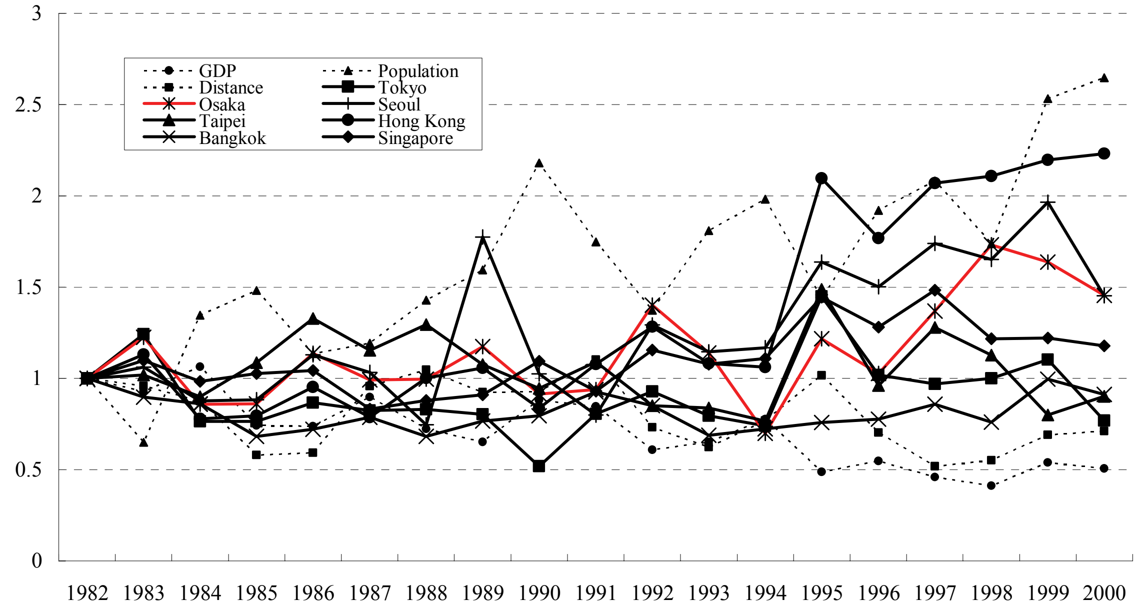


Figure 5. Time-Series Changes on Each Estimated Value of Parameters from 1982 to 2000
(Cargo)

Next, in order to examine the temporal changes in the estimated values of parameters, the same analysis was applied to the international air traffic flows from 1982 to 1999, as well. The results for passenger are shown in Figure 4 and those for cargo in Figure 5 with each value divided by that for 1982. The GDP, population and distance parameters for passenger, as a whole, declined over the period. This is also the same case with respect to the GDP and distance parameters for cargo, although the population coefficients increased in size. The decline in the distance parameters for passenger implies air travelers are increasingly making their trips with less regard to their journey length, which may have implications for the development of hub-and spoke systems (HASS) in international aviation. Regarding the parameters for GDP, the analysis reflects its decreasing importance as a driver for international air traffic flows as differences in the economic power of

Asian nations have diminished. Furthermore, the trend of changes in the estimated values of parameter for population may be influenced by the globalization of plant location. Regarding cargo, it may reflect the increased vertical division of labor, e.g., caused by Japanese firms moving their production to ASEAN nations. As far as the trend of changes in the estimated values of parameter for dummy variables for passenger is concerned, Tokyo, Seoul and Hong Kong were increasing, with Osaka, Taipei, Bangkok and Singapore remaining nearly constant. The rise of Tokyo's value was remarkable from 1989 to 1995, which was almost certainly due to the appreciation of the yen during that period. For cargo, the dummy variables indicate that Osaka, Seoul and Hong Kong were on a positive trend, with Tokyo, Taipei and Singapore remaining nearly constant and Bangkok declined. Osaka may be judged to make the latent demand for international air cargoes appear by dint of a new airport. Tokyo's decline may be attributed largely to the limited capacity of its international airport. In summary, the hub-ness of Tokyo and Hong Kong seems to have increased between 1982 and 2000, while Singapore retained its strong hub-ness. It is also worth noting that the hub-ness of Seoul for both passenger and cargo is remarkably increasing. It is now proceeding with its hubbing strategy to become the pre-eminent connecting base of international aviation in Asia.

4. EFFECTS OF KANSAI INTERNATIONAL AIRPORT ON HUB-NESS OF OSAKA

4.1 Outline of Kansai International Airport (KIX)

In the previous section, the hub-ness of Osaka, especially for cargo, is increasing after the opening of a new international airport. In this section, the effects of Kansai International Airport (KIX) on the hub-ness of Osaka are, more in detail, examined by panel data analysis introducing 'new airport-dummy variable'. Before that, the historical backgrounds and the current situations of KIX are shortly summarized.

Initially, Osaka International Airport (ITM) functioned as the international airport in the Kansai Area before KIX opened. ITM is small, the area of which is 317 hectares with two runways of 3,000m×60m and 1,828m×45m. It is very conveniently located in the middle of an urbanized area, so environmental problems have been most serious and many controversies have occurred between the Government and the resident groups. On the other hand, the need for a new airport in this area was recognized, by the middle of the 1960's, in order to accommodate rapidly growing air traffic demand. With these backgrounds, KIX opened on the forth of September, 1994 and replaced the international operations of ITM. At present, KIX functions mainly as international airport and ITM only as domestic one.

Table 3 shows the outline and scheme of KIX. It is 510 hectares of area and has one runway of 3,500m×60m. In 2007, it is scheduled to partly complete the Stage II which includes the building of second runway of 4,000m×60m. In the final scheme, it will be 1,300 hectares of area and have three runways in all.

Table 3. Outline and Scheme of Kansai International Airport

Phase	Stage I	Stage II	Final
Year	1994	2007	—
Area (ha)	510	1,055	1,300
Runways	3,500m×60m×1	3,500m×60m×1 4,000m×60m×1	3,500m×60m×2 4,000m×60m×1
Aircraft Movements (,000)	160	230	260-300

Note: Stage II will be partly completed in 2007.
Source: Kansai International Airport.

According to Table 4, KIX has been increasing the number of flights and routes etc. after the opening. The capacity of ITM was so limited that there were only 194 international flights per week, 15 airline companies entered and 28 cities in 13 countries/regions connected. But now, KIX has 692 international flights per week (airliner: 567, freighter: 125) of 52 airline companies (airliner: 45, freighter: 23), connecting with 76 cities (airliner: 60, freighter: 39) in 32 countries/regions (airliner: 29, freighter: 19). KIX has relatively more cities connected to Asia, as shown in Figure 6. As of 2004, fifty out of the total 76 cities connected with KIX were Asian ones, accounting for 66%. The case was the same with the number of flights and airline companies. Thus, the following analysis is focused on Asia.

Table 4. Temporal Changes on Number of Flights and Routes at Kansai International Airport

	Pre-open (ITM)	1994/summer	2000/summer	2004/summer
Flights per week	194	338	676	692
Airline Companies	15	29	52	52
Countries/Regions	13	21	30	32
Cities	28	44	73	76

Note: ITM is Itami Airport (Osaka International Airport), which was the former international airport in Osaka.
Source: Kansai International Airport.

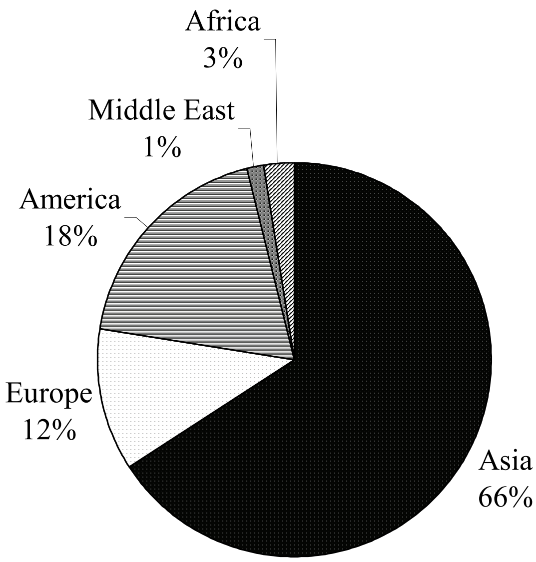


Figure 6. Proportion of Cities connected with Kansai International Airport by Each Region in 2004/Summer
Source: Kansai International Airport

4.2 Model Specifications

Panel data analysis with new airport-dummy variable is applied in this section to reveal the trend on the hub-ness of Osaka after the opening of KIX. The equation estimated here is a gravity model, which is almost the same in Section 3. The specifications of the model are made separately for passenger and cargo. Here, the explained variables are net international air passenger or cargo flows between Osaka and the seven Asian cities; Seoul, Pusan, Taipei, Hong Kong, Manila, Bangkok and Singapore. There exists only these seven cities connecting consecutively to Osaka before and after the opening of KIX, that is, from 1982 to 2000. The explanatory variables are GDP, population of urban agglomeration and distance. On top of these variables, in order to examine the effects of KIX on the hub-ness of Osaka, 'new airport -dummy variable' is introduced after 1995, not 1994, enough to reflect well the effects of KIX. 'e' raised to the power of the coefficients of dummy variable indicates how many times Osaka, after 1995, generates and absorbs international air passengers or cargoes explained by the basic gravity model composed of GDP, population and distance. In this analysis, these values are interpreted as the effects of KIX on the hub-ness of Osaka.

That is,

$$V_{oit} = A \frac{(G_{ot}G_{it})^{\alpha}(P_{ot}P_{it})^{\beta} e^{\delta D}}{(R_{oi})^{\gamma}} \tag{3}$$

Here,

V_{oit}: Volume of net international air passengers over ten thousand or volume of net international air cargoes over one hundred tons between Osaka and city_i in year_t

G_{ot}: Real GDP per capita in year_t of Japan expressed in US dollars at the exchange rate of year_t at the constant 1990 prices

G_{it}: Real GDP per capita in year_t of the country of city_i expressed in US dollars at the exchange rate of year_t at the constant 1990 prices

P_{ot}: Population of Osaka in year_t in thousands

P_{it}: Population of city_i in year_t in thousands

R_{oi}: Distance between Osaka and city_i in kilometers

D: New airport-dummy variable

A: Constant

Transforming equation (3) to log-form,

$$\ln V_{oit} = \ln A + \alpha \ln G_{ot}G_{it} + \beta \ln P_{ot}P_{it} + \delta D - \gamma \ln R_{oi} \tag{4}$$

4.3 Results and Interpretation

After applying ordinary least squares regression analysis to equation (4), the results were interpreted focusing mainly on the new airport-dummy variable.

Table 5 shows the results on each estimated value of parameters. Adjusted R^2 is relatively high enough to show the fitness of this model. Judging from the t-values, the estimated values of

Table 5. Regression Coefficients in Osaka

		Passenger	Cargo
Constant	lnA	2.41	-8.14
		(1.33)	(-2.99)
GDP	α	0.43	0.60
		(12.68**)	(12.00**)
Population	β	0.24	0.41
		(3.23**)	(3.58**)
Distance	γ	0.25	0.12
		(5.00**)	(1.62)
New-airport Dummy	δ	0.13 [1.14]	0.66 [1.94]
		(1.51)	(5.20**)
Adj.R^2		0.57	0.64
D.F.		133	133

Note: Figures in parentheses are t-values; ** indicates significant at the 1% level.
Figures in [ ] are e raised to the power of the coefficients of dummy variable.

parameters are significant at the 1% level except for that of new airport-dummy for passenger and that of distance for cargo. It can be said that this model explains most of the international air traffic flows between Osaka and the seven Asian cities.

Regarding the explanatory variables, the estimated values of the GDP parameter, α, as well as those of the population parameter, β, for both passenger and cargo are larger and those of the distance parameter, γ, for both passenger and cargo are smaller, compared with the results in Table2. Especially, that of the GDP parameter for cargo makes a great difference. This will be because this analysis was applied mainly to the international air traffic flows between Osaka and NIEs3 (Korea, Taiwan and Singapore) plus Hong Kong, which are economically developed in Asia and geographically located near Osaka.

With regard to the new airport-dummy variable, the estimated values of parameter, δ, for both passenger and cargo are over zero, which indicates KIX might ignite the potential demand for international air traffic in the Kansai Area. In particular, the case for cargo is remarkable. This is partly because not a few cargoes in this area, which were exported or imported via Tokyo before the opening of KIX, came back to Osaka after it opened. This result is consistent with the trend described in Figure 5. Statistics involving the raising of ‘e’ by the coefficients of new airport-dummy variable partly reveal the hub-ness of Osaka strengthened by dint of KIX.

5. SUMMARY AND CONCLUSIONS

The chief objectives of this paper are three-fold: to analyze the international air network structures in the context of relationships or connectivity across major cities in Asia, to reveal the degrees of hub-ness for Asian major cities by a gravity model and to examine the effects of KIX on the hub-ness of Osaka by panel data analysis. In terms of international urban systems, Tokyo, Hong Kong and Singapore are ranked in the first tier in Asia. By means of the gravity model composed of GDP, population and distance introducing city-dummy variables, the degrees of hub-ness for prospective seven hub cities in Asia have been revealed to some extent. In Asia, Tokyo, Hong Kong and Singapore hold supremacy as the hubs in this region insofar as international air traffic is concerned, with Seoul preeminently showing itself as greatly strengthening its hub-ness. From the temporal analysis, it may be predicted that these cities with positive results will strengthen their hub-ness in this region. In fine, all these, to a certain degree, serve to disclose the hub-ness of cities in terms of international air transportation. According to panel data analysis with the new airport-dummy variable, Osaka is reinforcing its hub-ness, particularly for cargo, after the opening of KIX.

Changes in hubbing are expected to result from various factors such as changes in the growth of national economies, changes in aircraft technology, e.g., allowing longer hauls, changes in the types of passengers carried, e.g., a split between business and leisure travel, changes in the availability of airport capacity and changes in bilateral air service agreements. In particular, the formation of global alliances among airlines is, at present, one of the key factors in the changing patterns of hubs. In addition to the above factors to be considered, there are also some problems left in the analysis to be addressed. First, the data used here are insufficient due to the data availability. More complete data are essential to improve the analysis here. Second, the analysis presented in this paper does not reflect the influence of capacity limitation in airports. For example, the real volume of airport traffic in Tokyo may be smaller than the theoretical volume because of the limited capacity of its airport. Third, strategic behavior among airport authorities, airlines and their users is not taken into consideration. For instance, Seoul, which is now proceeding with its hubbing strategy to become an international aviation hub in Asia with enough airport capacity, and Singapore, which has been adopting highly efficient airport management, are not fully evaluated in this paper. And finally, although the meaning of city-dummy variables in the gravity model is here interpreted as the hub-ness of cities, more careful consideration regarding this will be necessary.

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