Urban Competitiveness in the Space of Airline Flows

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Abstracts

This paper is examined the urban network structure of airline flows in terms of passengers and cargos by analyzing the 2008 O-D data for 74 cities collected by Korea Transport Institute, throughout factor analysis and network analysis. Eighty airports and seventy four cities are included in the analysis of passenger flows and seventy three airports and seventy three cities are included in the analysis of cargo flows.

The passenger flows place London at the first rank, followed by Hong Kong, Paris, Frankfurt, Singapore and Bangkok in 2008, showing the fast growing role of Asian Cities in the international air traffics. In comparison with urban ranks of air passenger flows in 1992, London, Paris and Frankfurt have hold their dominant global positions, but New York slide down its rank from 5th to 14th and San Francisco and Chicago move forward their position within 20 largest urban places. It is noticeable that Hong Kong, Singapore, Beijing and Shanghai moved forward in ranks, while Tokyo and Osaka slide down their rank in global airline network. Incheon airport opened in 2001 takes 10th position in rank has moved to 12th rank in 2008 in air passenger traffics.

However, the story would be different in cargo air traffics. The polarized patterns among Tokyo, New York and Frankfurt during the 1990s have shifted toward more important plays among Asian Cities in cargo flows. The American cities like New York, Chicago, and LA continuously slide down their position in global ranks, while Asian cities like Hong Kong, Shanghai, Incheon, Tokyo, and Singapore take five high ranks in global network thanks to strong role of Asian countries in the global production network. It is noticeable that the rank of Tokyo slightly moved downward after Shanghai and Incheon in air cargo traffics.

The Factor analysis draws out seventeen factors over one eigenvalue with 90% explanatory power in air passenger flows and fourteen factors with 86% of explanatory power in air cargo flows. In passenger flows, Paris, Dubai, Singapore, Tokyo, Madrid, New York, Beijing, Shanghai, Incheon, Vienna, Munich, Delhi, Moscow, and Auckland show dominant role as hub centers in connection with other regional cities in order. Especially, Tokyo and Shanghai show strong connection pattern globally and locally. Cargo flows reveals strong role of such cities as Singapore, Hong Kong, Frankfurt, Shanghai, Paris, Incheon, Tokyo, London, New York, Beijing, Amsterdam, Almaty, Sao Paulo and Munich in order in the global air cargo network. Incheon has strongly connected with Tashkent in passenger flows and with Nadi, Shanghai, Shenzhen and Vienna in cargo flows.

The global network index shows the hierarchical structure of Asian urban places in air passenger flows, placing Hong Kong in the first place followed by Bangkok, Tokyo, Singapore, Incheon, Beijing, Shanghai, Taipei, Kuala Lumpur, Mumbai, Delhi, and Osaka. Concerning air cargo flows, Hong Kong takes the first place in rank followed by Incheon, Bangkok, Kuala lumpur, Tokyo, Mumbai, Osaka, Singapore, Guangzhou, Almaty and Beijing, which reflected the international production network. Hong Kong shows the strong connectivity both in passenger and cargo flows. Incheon reveals stronger hub role in cargo flows than in passenger flows.

1. Introduction

The idea of global network means that no single city is not standing alone, but city network is constructed in any urbanizing region, suggesting that cities need other cities. What were the processes that created global cities and held those cities together? The answer would provide a glimpse of a worldwide configuration of inter-city relations in the contemporary world city network. Bradel(1984;22) defines a world economy as ‘an economically autonomous section of the planet able to provide for most of its own needs, a section to which its internal links and exchanges give a certain organic entity’. Cites with international destines are at the logistic heart of the world economy, which carried out two features; first, they are not isolated, they need other cities to become necessary nodes in circuit of flows; second, world cities change as part of the development of world economy, which means one city necessarily dominates.

The inter-city relations have been conceptualized from the 1960s through to the 1990s at the center of systems idea(Horton, 1970; Bourne, 1975; Bourne and Simon, 1978;; Hall and Hay, 1980; Wheeler, 1980; Johnston, 1982; Pred, 1997). Brian Berry(1964) formulated the idea of ‘cities as systems within systems of cities’. It is clearly stated that systems thinking is necessary in order to bring a huge intellectual baggage with system to figure out inter-city relations. The nature of urban system has been discussed with definition of ‘a set of interdependent cities comprising a region or nation’, which give an idea that city is seen as a part of larger system in relation to hierarchical nature of cities. For instance, a national system is dominated by metropolitan centers and characterized by a step like hierarchy. However, the characteristics of openness in the systems thinking bring questions of the validity of the coherence of national urban system in the globalizing international urban economy. The vital importance of international scale has led to the idea of globalization of cities for inter-city relations at a new larger than national scale.

Jean Gottmann(1961) developed the concept of ‘megalopolis’ to describe the pattern of urbanization linking US cities around the great lake region along to east coastal region. He was considering megalopolis as a chain of national and international crossroads with multiple networks of linkages to the world. In this line of international scale, the literature of ‘world city’ has been developed by several researchers despite minor variation of its meanings. Friedmann’s (1986) ‘world city hypothesis’, Saskia Sassens’s(1991) ‘global cities’ and Manuel Castells’91996) ‘space of flows’ in a network has been widely recognized as major conceptual framework in the world cities literature. Fridmann (1995) emphasized spatial articulation about a global vision of inter-city relations, a way of seeing transnational connections between cities in a hierarchical structure, which comprised three continental distinct subsystems focusing on New York, London and Tokyo respectively. Sassen (1991) has added new thinking in her detailed study of New York, London and Tokyo as global cities. She described inter-city relations as the emerging transnational urban system, putting more emphasis upon the production of financial and service products in a global hierarchy.

For Castells(1996) the analysis of global cities provides the most direct illustration of the space of flows in nodes and hubs to constitute a network. He argues that global city phenomena cannot be reduced to a few urban cores at the top of the hierarchy. Instead, he postulates a global network connecting centers with different intensity and at a different scale. Castells views that cities are part of space of flows in new network society. According to Castells(1996), in network society, the dominant form of space is not spaces of places, but a space of flows. The space of flows can be defined as a combination of layers of material supports for dominant social practices. Three layers are mainly identified. The first layer is the layer of circuit of electronic impulses based on communication and information devices, so called infrastructure support for social practices, ranging from the global internet to global airline network. The second layer is so called sandwich structure, the space of social practices that define society, which is constituted by agents who use the infrastructure network to link places. In this layer, we can identify the places of operation, termed nodes and hubs, that function to coordinate interactions across the network. The third layer is constituted by the spatial organization of economic elites that support the interests and practices of technocratic-financial-managerial elites. From this perspective, we can examine both the infrastructure layer and the latent structure of second layer of social practices by analyzing the international airline network in the space of flows. The airline network would be concrete skeletal infrastructure network of global economy where people make the system work behind. Airline flight network can become an easy and visible measure for inter-city connections. People should move around place-to-place in spite of advancement of telecommunications because face-to-face contact still remains significant in forming social relations in uncertain world. By airline network, transnational corporations are able to channel their human resources, information and merchandise globally in more reliable way.

Analyses of airline flights have revealed the inter-city connections easily represented by airports (Keeling, 1995; Rimmer, 1998; Smith and Timberlake, 1995; Short and Kim, 1999). Keeling(1995) analyzed world city connections based on flights routes among 256 cities over million population. Other researches have examined passengers and flights routes and schedule to reveal global urban hierarchy and world city network (Choi, *et.al*., 2006; Lee, 2008, 2009); to measure urban competitiveness(Sit, 2004); and to figure out airline network and airline transport by continents(Cattan, 1995; Ivy, 1995; O'Connor and Scott, 1992). However, it should be noted that airline flows are problematic measures of relations between world cities due to the state centric biases in data available. Moreover, Airline passenger flows are constituted by many processes outside world city process reflected in gross figures. For instance, the most popular holiday destination produce biased high ranking among world cities. It should be noticed that the ranking is not the same as showing a hierarchy in significance. The rankings of cities in air traffics are only ordering by size measures, slightly suggesting the elements of global hierarchical structure of connectivity.

This paper focuses on both the urban network structure of airline flows in terms of passengers and cargos and the evaluation of urban competitiveness in terms of airline flights mainly in Asian countries. It is using compiled O-D matrix data for the year of 2008 among 74 cities collected by Korea Transport Institute. Social network analysis and factor analysis has been done to find out network structure of airline flights as well as to evaluate the degree of inter-city connectivity. Eighty airports and seventy four cities are included in the analysis of passenger flows and seventy three airports and seventy three cities are included in the analysis of cargo flows.[1] For air passengers, total number of air routes among 80 cities is 2,236 and total passengers of all air routes are 388 million. Average air passengers per air route are 166,119 and average traffic volume of each city is 4,850,676.

2. Data and Analysis

First, the concept of social network analysis has been used to examine the spatial interactions between cities, so to speak to analyze functions and roles the cities in the structure of the international air network. The network methodology is useful to clarify the pattern of the inter-city connections as well as the whole network structure in the analysis of flows, exchanges and linkages between nodes (Smith and Timberlake, 2002). Also, it can be

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[1] In the case of passenger, cities like Tokyo, Shanghai, Moscow, Paris has two airport. London has three airports. Seoul and Incheon airport count separately. For cargos, DME(Moscow), GMP(Incheon), HND(Tokyo), LGW(London), ORY(Paris), SHA(Shanghai), and STN(London) are excluded in the analysis.

used to explain urban competitiveness of each city by analyzing the flows of international commercial flights and international trades, as well as to understand the hierarchy that is formed through the interactions between cities (Scott, 2000; Lee and Kim, 2010).

This study adopts a modified social network analysis model in the examination of the international air network that is used by Lee (2008) rather than to use the equations of the social network analysis method without a spatial concept. Therefore, the international air routes and cities are analyzed by examining the structure of the international air network, using indices such as the total traffic volume of each city, the traffic volume and the number of air routes. The connectivity of air routes is analyzed based in the local centrality of two cities and the traffic volume between them. The equation for the connectivity(C_{ij}) between two cities, i and j, is:

$$C_{ij} = \frac{f_{ij}}{m} \times L_i \times L_j$$

where
m is average traffic of all air routes,
f_{ij} is round-trip traffic between city i and j, and
L_i is the local centrality of city i and L_j is that of city j.

Here, the local centrality (L_i) of city i is measured based on the number of cities connected to it via non-stop flights, and the total traffic volume in the city. Its equation is as follows:

$$L_i = \frac{T_i}{g-1} \times \sqrt{\frac{F_i}{M_g}}$$ where

g is the total number of cities in the whole network,
T_i is the number of cities directly connected to the city i,
M_g is average total traffic of all cities, and
F_i is total in the city i.

Global network index (*Ni*) for city *i* which shows the degree of urban competitiveness in airline network can be calculated as follows:

$$N_i = \sum_{i=1}^{g} C_{ij}$$

(where C_{ij} is connectivity between two cities)

The interactions between two cities used to be often explained solely on the basis of the traffic volume between such cities. In this study, the connectivity means an air route's position in the air network. It gives weight to the local centrality of destinations and origins to draw connections between cities with high international network ability. Accordingly, although two air routes may have the same number of passengers, their positions in the air network may be entirely different, depending on what cities are connected by the air route. As this centrality in the international air network also is measured by the number of air route and the total traffic volume of a city, the local centrality refers to the inter-city direct connections in the international air network.

Second, factor analysis is the useful techniques to show hidden structure or dimensions in the inter-regional flows. Thus, the study investigates the patterns of air traffics in application of R-mode factor analysis for 80 x 80 O-D matrixes with Varimax rotation. Generally, the factor loadings above 0.50 are considered as significant destinations in airline flows, while the highest factor scores indicate dominant origins for each factor similar to Goddard method. Topological positions for relevant factors can be shown the whole network structure in the diagram.

3. Network Characteristics of Air passengers and Air Cargo flows in Urban Rank

1) Urban Competitiveness In Terms Of Air Traffic Volume, Routes And GNI

Since 1992, the rank of the world's major airports has been changed. For the passenger, European cities like London, Paris and Frankfurt continued to maintain their highest position, while in the Americas and Asia, especially since 2001, considerable variations in urban rank have been noticed. For example, Los Angeles, San Francisco and Chicago ranked slightly higher in the United States while the rank of New York has declined significantly from 5th in 1992 to 8th place in 2001 through to 14th in 2008.

Most noticeable changes are found in Asia in air passenger flows. Hong Kong decreased from 5th in 1992 to 8th place in 2001 but rising again to second place just after London. Singapore has also increased its rank from 6th to 5th during 2001 - 2008. Bangkok also shows the increase of its rank from 9th to 6th thanks to its location in the middle of East and West as well as the strong history of tourism. Kimpo airport in Korea used to take 9th rank in 1992, but decline its rank to 10th in 2001 when new Incheon airport opened. Recently, Incheon international airport is appearing only 12th rank. However, the biggest change can be found both at the Japanese airports that are falling and at the Chinese airports that are rising to the rank. Tokyo's long time leading position in Asia is challenged by Beijing, and is placed after Hong Kong, Singapore, and Bangkok. Also, Osaka is disappeared from top 20 airports. Both Beijing at the top 8th and Shanghai Pudong at the 16th have emerged as new top airports(Table 1).

Table 1. Changes of Total Volume of Air Passengers in Rank

Rank \ Year	1992	2001	2008
1	London	London	London
2	Tokyo	Paris	Hong Kong
3	Paris	Tokyo	Paris
4	Hong Kong	Frankfurt	Frankfurt
5	New York	Hong Kong	Singapore
6	Frankfurt	Singapore	Bangkok
7	Singapore	Amsterdam	Tokyo
8	Amsterdam	New York	Beijing
9	**Seoul**	Bangkok	Los Angeles
10	Bangkok	**Seoul**	Amsterdam
11	Taipei	Madrid	Madrid
12	Los Angeles	Los Angeles	**Incheon**
13	Rome	Zurich	Dubai
14	Zurich	Osaka	New York
15	Madrid	Copenhagen	Taipei
16	Copenhagen	Toronto	Shanghai
17	Milano	Taipei	San Francisco
18	Brussels	Stockholm	Barcelona
19	Honolulu	Brussels	Rome
20	Miami	Kuala Lumpur	Chicago

Source: Nam and Lee(2004), KOTI(2008)

Table 2. Changes of Total Volume of Air Cargos in Rank

Rank \ Year	1992	2001	2008
1	Tokyo	Tokyo	Hong Kong
2	New York	Hong Kong	Shanghai
3	Frankfurt	Singapore	**Incheon**
4	Hong Kong	**Seoul**	Tokyo
5	London	London	Singapore
6	**Seoul**	New York	Frankfurt
7	Paris	Frankfurt	London
8	Singapore	Paris	Paris
9	Los Angeles	Osaka	Amsterdam
10	Bangkok	Bangkok	Bangkok
11	Amsterdam	Amsterdam	Beijing
12	Taipei	Los Angeles	New York
13	Chicago	Chicago	Osaka
14	Zurich	Taipei	Chicago
15	San Francisco	Kuala Lumpur	Los Angeles
16	Sydney	San Francisco	Kuala Lumpur
17	Miami	Shanghai	Mumbai
18	Rome	Miami	Delhi
19	Kuala Lumpur	Sydney	Taipei
20	Osaka	Manila	Dubai

Source: Nam and Lee(2004), KOTI(2008)

The cargo flows have shown considerable variations in urban rank different from passenger flows. In cargo flows, the polarized patterns among Tokyo, New York and Frankfurt during the 1990s have diluted since 2001 as other Asian cities are playing more important roles in cargo flows(Table 2). The American cities like New York, Chicago, and LA continuously slide down their position in global ranks. It is because United States has played significant role as service centers, especially in advanced producer services in world economy, and has focused on NAFTA by strengthening intra-regional trade. Therefore, the main airports in the United States and Europe are going to strengthen the intra-continent hub functions rather than inter-continental hubs. Europe has the higher proportion of intra-regional trade traditionally so that regional hub status would be kept in constant manner, as shown in Table 2.

When we compare the passenger volume with routes that directly link to other airport, we can find their relative higher degree of connectivity in the global airline network. European cities such as Paris, Frankfurt, Amsterdam, Zurich, Rome, Munich show comparatively higher ranks in passenger routes than passenger volume. It means that they have more direct links with other cities in airline routes. Combining volume with routes produces the global network indices (GNI). In terms of GNI, seven Asian cities such as Hong Kong, Bangkok, Tokyo, Singapore, Incheon, Dubai and Beijing are in the top twelve airports in the global passenger network. The rest five are composed of four European cities (London, Paris, Frankfurt and Amsterdam) and one American city (New York) shown in Table 3 and Table 5.

Table 3. Urban Rank for Air Passengers in 2008.

Rank	Passengers volume	Passenger Routes	GNI for Passengers
1	London	Paris	London
2	Hong Kong	Frankfurt	Paris
3	Paris	London	Hong Kong
4	Frankfurt	Amsterdam	Frankfurt
5	Singapore	Bangkok	Bangkok
6	Bangkok	Zurich	Amsterdam
7	Tokyo	Dubai	Tokyo
8	Beijing	Rome	Singapore
9	Los Angeles	Munich	New York
10	Amsterdam	Incheon	Incheon
11	Madrid	Beijing	Dubai
12	Incheon	New York	Beijing

Table 4. Urban Rank for Air Cargos in 2008.

Rank	Cargo volume	Cargo Routes	GNI for Cargo
1	Hong Kong	London	Hong Kong
2	Shanghai	Frankfurt	Incheon
3	Incheon	Amsterdam	Shanghai
4	Tokyo	Paris	Tokyo
5	Singapore	Incheon	Frankfurt
6	Frankfurt	Hong Kong	Singapore
7	London	Zurich	London
8	Paris	Singapore	Paris
9	Amsterdam	Munich	Amsterdam
10	Bangkok	Tokyo	Beijing
11	Beijing	Beijing	New York
12	New York	New York	Bangkok

Table 5. Volume, Routes, Global Network Indices of Air Passenger Flows by Cities in 2008.

Airport(City)	Passengers		Routes		Global network analysis		Airport(City)	Passengers		Routes		Global network analysis	
	volume	Rank	number	Rank	GNI	Rank		volume	Rank	number	Rank	GNI	Rank
AKL(Auckland)	2,095,320	57	17	58	0.9181	61	LAX(Los Angeles)	11,293,854	9	36	28	28.3264	13
ALA(Almaty)	446,144	77	14	65	0.0889	73	LCA(Larnaca)	1,491,915	65	26	47	1.1244	58
AMS(Amsterdam)	10,883,291	10	55	4	44.2615	6	LGW(London)	2,913,450	49	28	43	2.7968	47
ATH(Athens)	3,954,936	38	39	20	7.6610	31	LHR(London)	19,141,767	1	59	3	108.4484	1
ATL(Atlanta)	4,943,741	31	35	30	8.1301	30	LIS(Lisbon)	3,356,925	42	28	44	4.5998	42
BCN(Barcelona)	7,265,489	18	32	37	16.1411	20	LUx(Luxembourg)	333,024	78	12	69	0.0713	77
BKK(Bangkok)	12,512,737	6	51	5	49.1713	5	MAD(Madrid)	10,054,709	11	41	16	27.8363	14
BOM(Mumbai)	5,418,671	24	34	34	10.2821	27	MAN(Manchester)	2,928,389	48	32	38	4.4695	43
BRU(Brussels)	4,222,296	35	36	26	7.0732	32	MEX(Mexico City)	2,136,738	55	15	64	1.1380	57
BUD(Budapest)	2,112,901	56	33	36	2.5437	48	MFM(Macao)	1,613,389	63	12	70	0.5257	66
CAI(Cairo)	2,903,982	50	37	22	4.3120	44	MNL(Manila)	4,645,560	33	24	49	6.2874	35
CAN(Guangzhou)	5,007,119	30	24	48	5.7899	36	MUC(Munich)	6,711,567	21	50	9	21.1624	17
CDG(Paris)(Paris)	13,930,998	3	61	1	71.2374	2	MXP(Milan)	5,039,090	29	45	13	12.1113	24
CGK(Jakarta)	3,420,330	41	15	61	2.4042	50	NAN(Nadi)	274,216	79	5	78	0.0112	79
CMB(Colombo)	1,439,219	66	15	62	0.6859	64	NBO(Nairobi)	984,373	70	13	68	0.3838	68
CPH(Copenhagen)	5,396,297	25	36	27	11.0492	26	NRT(Tokyo)	11,783,374	7	43	14	43.0464	7
DCA(Dhaka)	1,395,470	68	11	71	0.4301	67	ORD(Chicago)	6,854,803	20	30	42	13.5118	21
DEL(Delhi)	5,094,934	28	35	31	9.4584	28	ORY(Paris)	1,607,322	64	17	59	0.6471	65
DME(Moscow)	1,837,719	59	30	41	1.7860	52	OSL(Oslo)	2,691,777	51	28	45	3.1236	46
DOH(Doha)	3,239,144	43	34	35	4.6546	40	PEK(Beijing)	11,512,202	8	48	11	31.7605	12
DXB(Dubai)	9,891,423	13	50	7	31.9677	11	PRG(Prague)	3,649,909	39	36	29	5.7493	37
ESB(Ankara)	217,284	80	9	73	0.0262	78	PVG(Shanghai)	8,435,081	16	37	23	23.5581	16
FCO(Rome)	7,001,726	19	50	8	23.8779	15	RGN(Yangon)	493,606	75	8	75	0.0872	74
FRA(Frankfurt)	12,797,963	4	60	2	60.7340	4	RUH(Riyadh)	1,627,966	61	21	54	0.8655	62
GMP(Seoul)	1,025,848	69	3	80	0.0049	80	SCL(Santiago)	858,745	71	9	74	0.1141	72
GRU(Sao Paulo)	2,436,459	52	18	57	1.7685	53	SFO(San Francisco)	7,926,915	17	24	50	12.7047	22
GUM(Agana, 괌)	638,158	73	7	76	0.0723	76	SHA(Shanghai)	5,270,249	26	5	79	1.0681	59
HAN(Hanoi)	1,424,323	67	15	63	0.7184	63	SIN(Singapore)	12,767,571	5	40	18	39.8817	8
HEL(HelSINki)	3,423,893	40	38	21	6.3048	34	STN(London)	842,647	72	17	60	0.2689	69
HKG(Hong Kong)	16,105,485	2	41	15	61.9768	3	SVO(Moscow)	2,997,814	46	37	24	4.7529	39
HND(Tokyo)	1,821,936	60	5	77	0.0846	75	SYD(Sydney)	4,155,771	36	24	51	4.1576	45
HNL(Honolulu)	3,149,548	45	14	66	1.5745	55	SZX(Shenzhen)	2,952,046	47	10	72	0.9470	60
ICN(Incheon)	10,022,557	12	49	10	36.1933	10	TAS(Tashkent)	481,064	76	19	56	0.1157	71
ISB(Islamabad)	569,693	74	13	67	0.1538	70	TLV(Tel Aviv)	3,228,423	44	37	25	5.6352	38
JFK(New York)	9,624,113	14	47	12	37.0144	9	TPE(Iaipei)	8,674,354	15	27	46	16.7624	19
JNB(Johannesburg)	2,273,516	53	22	53	2.3923	51	VIE(Vienna)	5,227,873	27	41	17	12.5075	23
KBP(Kiev)	1,615,970	62	35	32	1.6260	54	WAW(Warsaw)	2,198,360	54	31	40	2.4672	49
KIX(Osaka)	4,705,364	32	31	39	6.7532	33	YVR(Vancouver)	4,129,772	37	24	52	4.6005	41
KUL(Kuala Lumpur)	6,133,226	22	35	33	11.7326	25	YYZ(Toronto)	4,622,582	34	40	19	9.2073	29
KWI(Kuwait)	1,879,166	58	20	55	1.2541	56	ZRH(Zurich)	5,866,512	23	51	6	17.8873	18

Table 6. Volume, Routes, Global Network Indices of Air Cargo Flows by Cities in 2008.

Airport(City)	Freight		Routes		Global network analysis		Airport(City)	Freight		Routes		Global network analysis	
	cargo volume	Rank	Numbers	Rank	GNI	Rank		cargo volume	Rank	Numbers	Rank	GNI	Rank
ALA(Almaty)	122,805	21	14	53	5.190	21	LCA(Larnaca)	3,653	67	10	57	0.018	66
AMS(Amsterdam)	390,041	9	53	3	60.000	9	LHR(London)	459,787	7	59	1	81.487	7
ATH(Athens)	21,208	51	29	24	0.442	45	LIS(Lisbon)	12,755	57	23	35	0.121	58
ATL(Atlanta)	93,639	24	31	19	6.564	20	LUX(Luxembourg)	33,749	43	6	67	0.212	52
BCN(Barcelona)	15,821	55	23	34	0.179	54	MAD(Madrid)	50,901	37	32	18	1.447	33
BKK(Bangkok)	273,240	10	29	25	30.836	12	MAN(Manchester)	45,284	39	24	32	1.262	36
BOM(Mumbai)	161,198	17	24	31	9.781	19	MEX(Mexico City)	34,358	42	15	52	0.421	47
BRU(Brussels)	72,851	29	33	15	3.590	26	MFM(Macao)	7,119	61	10	58	0.018	65
BUD(Budapest)	5,372	64	14	54	0.021	63	MNL(Manila)	66,548	32	12	56	1.619	32
CAI(Cairo)	33,086	44	17	45	0.857	40	MUC(Munich)	66,444	33	40	9	3.183	28
CAN(Guangzhou)	74,476	28	19	40	2.367	30	MXP(Milan)	76,275	27	23	36	3.882	25
CDG(Paris)	449,146	8	52	4	75.076	8	NAN(Nadi)	408	73	4	71	0.000	72
CGK(Jakarta)	63,895	34	6	66	0.753	42	NBO(Nairobi)	79,524	26	8	61	1.260	37
CMB(Colombo)	36,200	41	15	48	0.652	44	NRT(Tokyo)	655,190	4	38	10	119.388	4
CPH(Copenhagen)	57,655	35	34	13	2.748	29	ORD(Chicago)	227,170	14	28	28	22.602	14
DAC(Dhaka)	21,336	50	7	63	0.146	56	OSL(Oslo)	17,421	53	19	41	0.402	48
DEL(Delhi)	135,170	18	30	23	10.813	17	PEK(Beijing)	270,591	11	36	11	32.935	10
DOH(Doha)	1,070	71	7	64	0.001	71	PRG(Prague)	7,111	62	31	21	0.084	59
DXB(Dubail)	129,388	20	31	20	10.106	18	PVG(SHANghai)	780,637	2	31	22	148.533	3
ESB(Ankara)	481	72	3	72	0.000	73	RGN(Yangon)	1,560	70	5	70	0.002	69
FCO(Rome)	27,464	47	29	26	0.814	41	RUH(Riyadh)	2,678	69	10	59	0.007	68
FRA(Frankfurt)	539,857	6	57	2	102.979	5	SCL(Santiago)	15,003	56	6	68	0.031	62
GRU(Sao Paulo)	67,445	31	15	49	1.157	39	SFO(San FRAncisco)	100,718	22	16	47	4.266	24
GUM(Agana)	5,990	63	5	69	0.017	67	SIN(Singapore)	572,941	5	43	8	92.539	6
HAN(Hanoi)	15,977	54	15	50	0.240	50	SVO(Moscow)	18,698	52	24	33	0.434	46
HEL(Helsinki)	41,076	40	32	17	1.374	34	SYD(Sydney)	91,673	25	22	38	3.295	27
HKG(Hong Kong)	1,113,464	1	46	6	287.505	1	SZX(Shenzhen)	30,284	46	8	62	0.234	51
HNL(Honolulu)	53,402	36	8	60	0.257	49	TAS(Tashkent)	5,072	65	18	44	0.020	64
ICN(Incheon)	740,619	3	49	5	181.508	2	TLV(Tel Aviv)	47,707	38	19	42	1.233	38
ISB(Islamabad)	2,981	68	1	73	0.002	70	TPE(Iaipei)	130,771	19	13	55	4.811	23
JFK(New York)	268,091	12	35	12	32.436	11	VIE(Vienna)	9,611	60	21	39	0.067	60
JNB(Johannesburg)	71,434	30	15	51	2.192	31	WAW(Warsaw)	12,551	58	29	27	0.200	53
KBP(Kiev)	4,349	66	34	14	0.037	61	YVR(Vancouver)	25,206	49	19	43	0.703	43
KIX(Osaka)	256,749	13	26	30	25.410	13	YYZ(Toronto)	32,835	45	28	29	1.311	35
KUL(Kuala Lumper)	177,655	16	33	16	14.244	16	ZRH(Zurich)	95,673	23	46	7	5.076	22
KWI(Kuwait)	10,278	59	16	46	0.121	57							

Air cargo flows show that Asian cities play more significant roles in global airline network and global economy in comparison with air passenger flows. Global top four cities in air cargo flows are all Asian cities. Hong Kong takes the first place followed by Incheon, Shanghai, Tokyo, Frankfurt, Singapore and London. Seven Asian cities, four European cities and one American city are listed in the global top twelve (Table 4, Table 6). The reason that Asian cities like Hong Kong, Shanghai, Incheon, Tokyo, and Singapore take higher ranks in global airline network would be strong role of Asian economies in the global production network. Asian countries have been central to be the production sites of the world. In Asia, high competition between Asian airports to become hub ports would be accelerated over due to rapidly increasing volume of intra and inter-regional trade in the world economy. European cities shows more higher ranks of the air cargo routes than those of air cargo volumes, implying their role of intra-regional hub airport with more direct links to other cities

The highest rank of Hong Kong would be associated with Chinese rapidly growing economy. However, it is noticeable that the rank of Tokyo has slightly moved downward after Shanghai and Incheon in air cargo traffics in 2008 (Table 2, Table 4). Tokyo used to bear the highest rank in cargo flows, but it being pushed to the next after Shanghai and Seoul in 2008(Table 2).

2) Dominant Flows Structure By Factor Analysis

(1) Air Passenger Flows

Factor analysis can be a useful method to reveal the hidden structure of dominant flows. Factor analysis for passenger flows draws out 17 valid factors accounting for 90% of total variations, while factor analysis on air cargos flows extracts 14 relevant factors accounting for 86.3% total variance. Concretely, factor 1 is accounting for 24.5% at large and then, factor 2 for 10.5%, factor 3 for 9% , factor 4 for 6.4%, factor 5 for 5.7%, factor 6 for 5.2, and others for below 3% each. So to speak, Factor 1 to factor 6 explains total 61.5% in significance for air passenger flows.

The dominant air passenger flows pattern shows considerable regionalized geographical pattern from origins to destinations with dominant directions worldwide. For instance, factor 1 is the Paris' nodal region, mainly covering European cities and American cities including Sao Paulo in South America and New York, Chicago, Toronto in North America. Factor 2 covers the Dubai's nodal region, worldwide connecting to African cities like Cairo, Johannesburg, Nairobi, and middle east and South Asian cities like Colombo, Delhi, Doha, Islamabad, Kuwait and Riyadh. Factor 3 cares Singapore's nodal region in strong connection with Southeast Asian cities and Australian cities like Sydney and Auckland. Factor 4 and Factor 17 are interpreted as Tokyo's nodal region. Tokyo's nodal region shows strong connection to Asian cities like Guam, Honolulu, Incheon, Shanghai, and Taipei as well as localized pattern with Osaka and Seoul (Kimpo). Factor 5 is the Madrid's nodal region covering Iberia peninsular and nearby London and Paris (Table 7).

Factor 6 and Factor 8 are covering New York's nodal region which is characterized by intra-regional domestic connections with Los Angeles and San Francisco. Factor 9 and Factor 14 is about Shanghai's nodal region, mainly connecting to regional cities like Hong Kong, Macao, Singapore, Tokyo and Beijing. Factor 10 is showing strong connection of Incheon to Tashkent in central Asia. Other factors are showing local nodal regions with strong regionalized pattern, such as Vienna to Moscow and Ankara (factor 11), Munich to London (factor 12), Delhi to Mumbai and Dhaka (factor 13), Moscow to Almaty (factor 15), Auckland to Nadi and Sydney (factor 16)(Table 7).

Air passenger flows would reveal the hub-spoke pattern around regional hub airport cities worldwide (Figure 1). However, it should know that major hub airports are identified by origin that generates passenger flows. That is why London is not showing as the major nodal city despite the highest rank of GNI and Paris becomes the major origin city in European continent.

Table 7. Factor loadings and Factor structure of Air Passenger Flows

Factor	Rotated factor loadings			Factor Structure (nodal region)	
	eigenvalue	% variance	% cumulative variance	Origin**	Destinations*
1	19.575	24.469	24.469	Paris	Amsterdam, Tthens, Budapest, Copenhagen, Rome, Sao Paulo, Helsinki, New York, Lisbon, Luxembourg, Madrid, Manchester, Munich, Milan, Chicago, Oslo, Prague, Moscow, Tel Aviv, Vienna, Warsaw, Toronto, Zurich
2	8.430	10.537	35.006	Dubai	Cairo, Colombo, Delhi, Doha, Islamabad, Johannesburg, Kuwait, Nairobi, Riyadh
3	7.253	9.066	44.072	Singapore	Auckland, Bangkok, Jakarta, Hanoi, Kuala Lumpur, Manila, Yangon, Sydney
4	5.169	6.461	50.533	Tokyo	Agama(Guam), Honolulu, Incheon, Shanghai, Taipei
5	4.587	5.734	56.267	Madrid	Barcelona, London, Paris, Santiago
6	4.225	5.282	61.549	New York	Los Angeles, San Francisco
7	2.883	3.604	65.153	Beijing	Guangzhou, Shanghai, Shenzhen
8	2.677	3.346	68.498	New York	New York
9	2.666	3.333	71.831	Shanghai	Hong Kong, Macao, Singapore
10	2.443	3.054	74.885	Incheon	Tashkent
11	2.203	2.754	77.639	Vienna	Moscow, Ankara
12	1.953	2.442	80.081	Munich	London
13	1.857	2.321	82.401	Delhi	Mumbai, Dhaka
14	1.822	2.278	84.679	Shanghai	Tokyo, Beijing
15	1.638	2.048	86.727	Moscow	Almaty
16	1.638	2.047	88.775	Auckland	Nadi, Sydney
17	1.431	1.789	90.564	Tokyo	Seoul, Osaka

*factor loadings > 0.6 **factor score >3.0

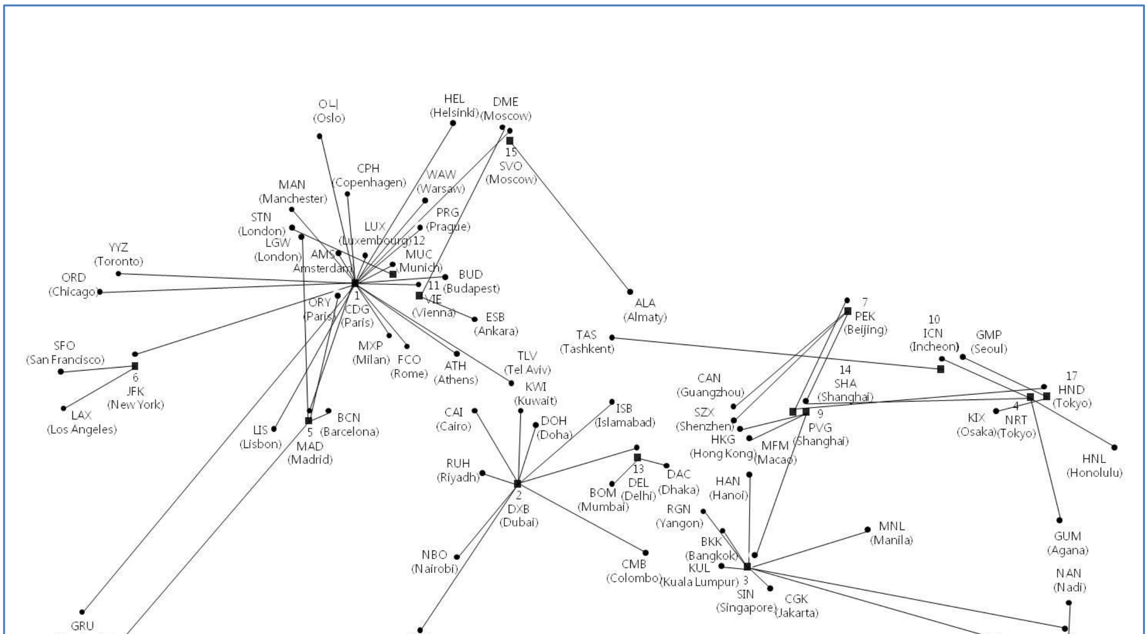

Figure 1. Diagram of Factor Structure for Air Passengers Flows

Table 8 Factor loadings for cargo flows

Factor	Rotated Factor Loadings			Factor structure (nodal regions)	
	eigenvalue	% variance	% cumulative variance	Origin**	Destination*
1	8.866	12.145	12.145	Singapore	Bangkok, Jakarta, Colombo, Dhaka, Delhi, Hanoi, Kula Lumpur, Macao, Manila, Yangon,
2	7.425	10.171	22.316	Hong Kong	Almaty, Manchester, Taipei, Vancouver, Toronto
3	7.308	10.011	32.327	Frankfurt	Athens, Doha, Nairobi, Prague, Riyadh
4	5.955	8.158	40.486	Shanghai	Amsterdam, Helsinki, Incheon, Osaka, Luxembourg, Tokyo, Singapore
5	5.721	7.838	48.323	Paris	Cairo, Sao Paulo, Madrid, Mexico City, Milan
6	5.412	7.414	55.737	Incheon	Nadi, Shanghai, Shenzhen, Vienna
7	4.339	5.944	61.681	Tokyo	Agana, Honolulu, Los Angeles
8	3.988	5.463	67.144	London	Athens, Islamabad, New York, Larnaca
9	3.917	5.366	72.510	New York	Brussels, London, Zurich
10	3.219	4.409	76.919	Beijing	Budapest, Copenhagen, Rome, Kiev, Tashkent
11	2.321	3.180	80.099	Amsterdam	Kuwait, Oslo, Moscow
12	1.634	2.239	82.337	Almaty	Frankfurt, Warsaw
13	1.491	2.042	84.380	Sao Paulo	Santiago
14	1.423	1.949	86.329	Munich	Munich

*factor loadings > 0.6 **factor score >3.0

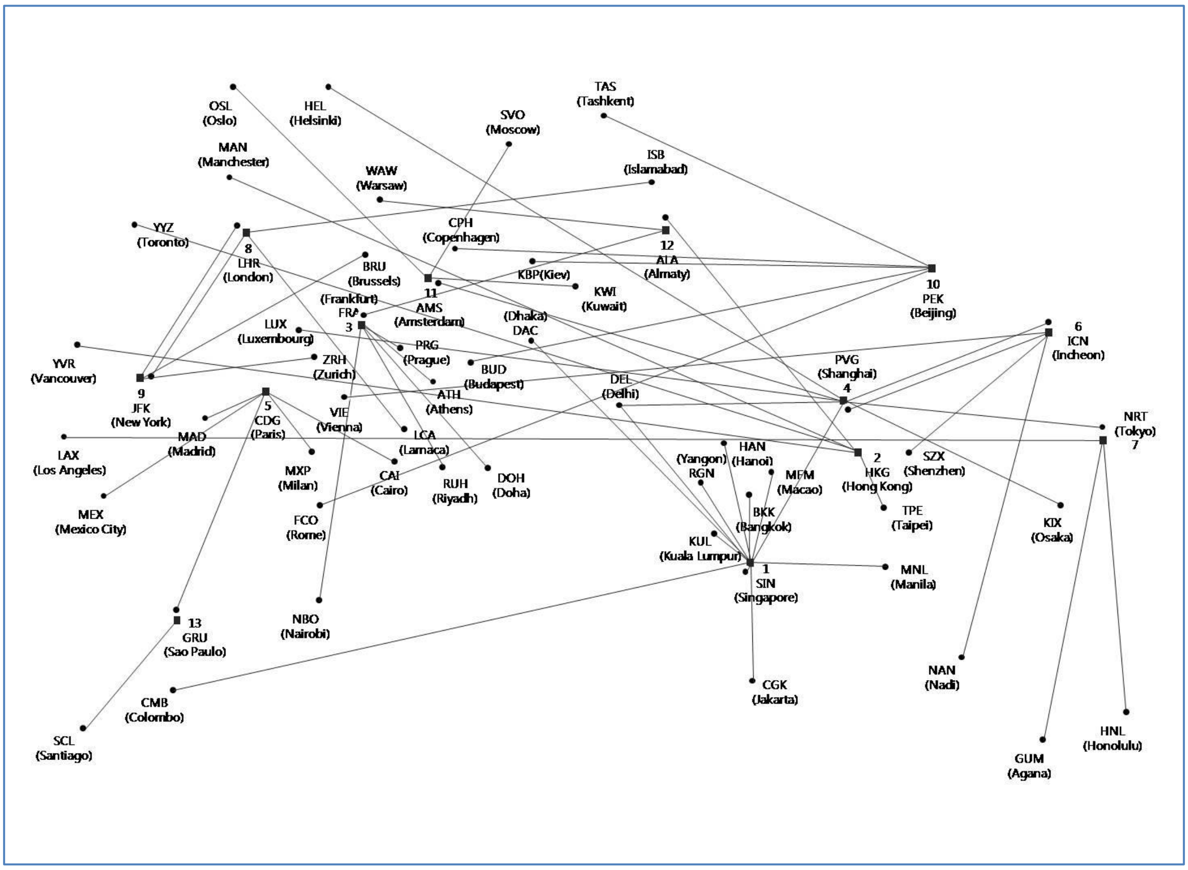

Figure 2. Factor Structure of Air Cargo Flows

(2) Air Cargo Flows

In the case of air cargo flows, nine factors are accounting for 72.5% of total variance. Factor 1 takes variance over 12%, followed by factor 2 and factor 3 for over 10% each. Air cargo flows would reveal less regionalized pattern than air passengers flows, showing scattered worldwide network pattern. It is because cargo flights are frequently based on irregular flights on demand.

Factor 1 covers the Singapore's nodal region where Singapore become an important origin with several destinations in Southeast Asian countries, including Bangkok, Jakarta, Colombo, Dhaka, Delhi, Hanoi, Kula Lumpur, Macao, Manila, and Yangon. Factor 2 is the Hong Kong's nodal region connecting Hong Kong both to Almaty, Taipei in Asia and Mancester, Vancouver, and Toronto. Factor 3 is about Frankfurt's nodal region where Athens, Doha, Nairobi, Prague, Riyadh are connected to. Factor 4 is Shanghai's nodal region, connecting to Asian cities like Incheon, Osaka, Tokyo, and Singapore as well as connecting to European cities like Amsterdam, Helsinki, and Luxembourg. Factor 5 is Paris' nodal region in connection to European cities like Madrid and Milan, as well as to South American cities like Sao Paulo and Mexico City, and to city of Cairo.

As of factor 6, Incheon's nodal region is strongly connected to regional cities such as Shanghai and Shenzhen, as well as to Vienna and Nadi in Fiji. Factor 7 shows Tokyo's nodal region covering Agama (Guam), Honolulu, and Los Angeles. Factor 8 is the London's nodal region that is connected to Athens, Islamabad, New York and Larnaca. New York is also showing strong connection to London in Factor 9 with Zurich and Brussels besides. As of factor 10, Beijing is connected to European cities like Budapest, Copenhagen, Rome, Kiev, and Tashkent. Other factors are appearing regionalized nodal patterns such as Amsterdam to Kuwait, Oslo and Moscow, Almaty to Frankfurt and Warsaw, Sao Paulo to Santiago, and Munich to Munich.

There are big differences between air passenger flows and air cargo flows. It is hardly to see any cross continental nodal regions in air passenger flows. Most of dominant flows in air passengers show the hub and spoke pattern around regional hubs (Figure 1). However, air cargo flows show more diversified worldwide pattern. Cross continental flow patterns are vividly observed in the diagram (Figure 2), implying the worldwide flows of merchandise goods throughout transnational corporations and global production chains.

Comparing passenger with cargo flows, several cities can be commonly found as generating points in the spaces of airline flows; Paris, Singapore, Tokyo, New York, Beijing, Shanghai, Incheon, and Munich (that shows strong self-connection not to others). Among these, five cities are located in the East Asia, suggesting significant role of gateway cities in the space of flows within the global economy.

4. Summary and Conclusion

This paper was examining the urban network structure of airline flows by using factor analysis and social network analysis for passengers and cargos data in 2008 in order to investigate relative status of urban competitiveness worldwide. The global network is constituted by nodes and hubs in the space of flows with different intensity at a different scale. Global airline network shows the layer of infrastructure and social practices as indicated in Castells' argument. Although ranking is not the best indicator for urban competitiveness, it might be meaningful indicator of the hierarchical structure of the connectivity in the global and one of relative power structure in the global society.

In this paper, Global network index(GNI) was calculated by considering total traffic volume, number of routes and local centrality to show the degree of urban competitiveness.

The result said that, for air passengers, London took the highest rank followed by Paris, Hong Kong, Frankfurt, Bangkok, Amsterdam, Tokyo, Singapore, New York, Incheon, Dubai and Beijing in order. For air cargos, rankings are different as follows; Hong Kong took the first place, and then followed by Incheon, Shanghai, Tokyo, Frankfurt, Singapore, London, Paris, Amsterdam, Beijing, New York and Bangkok in order. The fact strongly suggests the fast growing role of Asian Cities in the international air traffics as the factory of the world.

The Factor analysis revealed the structure of dominant flows in the global airline network. Air passenger flows showed that Paris, Dubai, Singapore, Tokyo, Madrid, New York, Beijing, Shanghai, Incheon, Vienna, Munich, Delhi, Moscow, and Auckland were forming regionalized nodal patterns. Cargo flows revealed less regionalized pattern, but more inter-continental worldwide connection pattern around cities like Singapore, Hong Kong, Frankfurt, Shanghai, Paris, Incheon, Tokyo, London, New York, Beijing, Amsterdam, Almaty, and Sao Paulo. Particularly, Incheon has strongly connected with Tashkent in passenger flows and with Nadi, Shanghai, Shenzhen and Vienna in cargo flows. GNI index indicated that Incheon took 10^{th} rank in air passengers and second rank in air cargo flows, showing stronger hub role in cargo flows than in passenger flows.

However, it should note the major discrepancy between the network connectivity rankings and the command function. For example, Incheon's high rank in the global connectivity does not necessarily mean that it has highest global command functions, although its position in the network can attract large number of transnational firms. It is surely the prime location for firms to service clients in the growing emerging market. Places and cities embody a network power through their network and geographical position, which form so called the gateway cities. The gateway functions are depending upon how to place their comparative advantages within the world city network and how to enhance their attraction level both in the space of places and in the spaces of flows. From this perspective, urban competitiveness is not only defined by global connectivity, but also by leading economic sectors that are dominating world city network formations, which requires key role in worldwide communities in terms of various activities including environmental issues, other global campaigns, and global service network.

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