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(Citation)

Journal of Air Transport Management, 71:160-166

(Issue Date)

2018-08

(Resource Type)

journal article

(Version)

Accepted Manuscript

(Rights)

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<https://hdl.handle.net/20.500.14094/90005066>



The effects of new international airports and air-freight integrator's hubs on the mobility of cities in urban hierarchies: a case study in East and Southeast Asia

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Abstract:

This paper examines international air traffic flows from, to and within East and Southeast Asia, and in turn the hub status of cities over the years from 1982 to 2012. Its focus of attention is the effects of new international airports and integrator's hubs on the mobility of cities in a region's urban hierarchy. The results reveal that Hong Kong, Shanghai, Guangzhou, Bangkok, Kuala Lumpur and Seoul are strengthening their positions as international air traffic hubs, all of which opened a new international airport. Meanwhile, three global air-freight integrators have constructed a global or regional hub in most of these cities. In contrast, Tokyo is downgraded from a top ranked global city during the period analyzed.

Key Words:

International air traffic; Urban hierarchies; New airports; Integrators; Gravity model and Asia

1. Introduction

Aviation market has drastically expanded over the past decades in Asia with strong economic growth and economic integration at both the global and regional levels. Passengers from, to and within Asia are expected to account for nearly half of global passenger traffic in the next 20 years, with an overall market size of 2.9 billion. Among the highlights is the expectation that traffic from, to and within China will account for 1.3 billion passengers, overtaking the US as the world's largest passenger market by 2030 (IATA, 2014). This region will also lead the world in the growth of air cargo traffic. Domestic China and intra-Asia markets will expand at the annual growth rate of 6.7% and 6.5%, respectively, while Asia-North America and Asia-Europe markets will grow slightly faster than the world average growth rate (IATA, 2014). In particular, international express market has been drastically growing. It continues to outpace the annual growth rate of international air cargo traffic, with its share from 4.1 % in 1992 up to 17.0 % in 2013 (Boeing, 2014).

Meanwhile, there are changes in hub roles as airlines shift toward mid-sized long-haul aircrafts, which are better suited to serving smaller cities (O'Connor and Fuellhart, 2015). These aircrafts can provide point-to-point links by-passing some hubs. That change may be facilitated by the construction of new airports in some cities. Asia has seen many examples of that, many of which are within the second ranked cities, positioned below the top ranked global cities. This can be seen in the opening of new international airports in the 1990's and 2000's in Shenzhen (1991), Osaka/Kansai (1994), Macau (1995), Kuala Lumpur (1998), Seoul/Incheon (2001), Guangzhou (2004), Nagoya/Chubu (2005), Tianjin (2005) and Bangkok/Suvarnabhumi (2006). The big hubs added new international airports in Hong Kong (1998) and Shanghai/Pudong (1999), while Tokyo/Narita, Tokyo/Haneda and Singapore/Changi responded by expanding their capacities, including new runways or terminals. Beijing and Ho Chi Minh City are scheduled to start a new international airport in 2019 and in 2023, respectively. Meanwhile, three global air-freight integrators, DHL, FedEx and UPS, have been developing their hub-and-spoke networks in this region by constructing global and regional hubs. Their Asian hubs are drastically changing the urban pattern of international air cargo transport within this region. Hence, there has been a major re-alignment in hub roles, providing the potential to change the hierarchical structure of hub cities.

This paper provides a contribution by showing the emerging global cities in East and Southeast Asia over the last thirty years with a focus on the second ranked cities. It employs a regression model incorporating a hub effect as an explanatory factor of its level of international air traffic. This will establish the strength of this factor in comparison with the

broadly based influences of GDP per head and population. This model was developed by Matsumoto (2004, 2007), which confirmed the supremacy of Tokyo, Hong Kong and Singapore, using the data on international air passenger and cargo flows up to 2000. The current paper explores the effects of new international airports and integrator's hubs on the mobility of cities in a region's urban hierarchy. The analysis will be carried out for 2012 and over the period from 1982 to 2012.

The remainder of this paper is organized as follows. The next section provides an overview of the literature on global urban hierarchies and world cities. In Section 3, a model is specified to explain international air traffic flows between cities, followed by a discussion of the results. Finally, the paper ends with a conclusion with future work in Section 4.

2. Literature review

To date, the issue of global urban hierarchies and world cities has been frequently discussed especially after the initial work of Friedmann (1986), mainly using two indexes: aviation networks (Smith and Timberlake, 1995; Taylor et al., 2007; Derudder et al., 2008; Grubestic et al., 2009; Lee, 2009) and corporate networks (Taylor et al., 2002; Alderson et al., 2010; Liu et al., 2014). These two criteria practically identify the same hierarchies of cities. Keeling (1995) underpinned that hierarchies of global cities in terms of international air traffic flows closely matched the location of headquarters of multi-national firms. Sassen (2012) showed that the connections between the operations of multi-national firms and global advanced producer services (APS) together would influence air connections between cities. Liu et al. (2013) explored the co-evolution of the geographies of aviation and corporate networks and confirmed that cities with well-developed aviation networks attract more globalized business service firms, while globalized business service firms in turn stimulate the development of aviation networks.

Much attention has been focused on world cities, which are significant clusters of multi-national firms and global business service firms and so play a prominent role in international air traffic. Thus, in the analyses of Asian cities, Matsumoto (2004, 2007) confirmed the prominent roles of Tokyo, Hong Kong and Singapore, while Mahutga et al. (2010) found that the most upwardly mobile city between 1977 and 1995 was Hong Kong and also found that Shanghai and Beijing ascended to the first and second ranked positions between 1995 and 2005, respectively. However, O'Connor (2003) and Sismanidou et al. (2013) showed that international air passenger movements began to favor a group of second ranked cities between 1990 and 2000. Asian examples included Seoul and Osaka. O'Connor and Fuellhart (2013) also found a shift in favor of a group of next largest cities over the

period from 2005 to 2010, identifying Mumbai and Guangzhou, in particular. As such, Asia is experiencing the dynamic change in a region's urban hierarchy. We can draw on other substantial studies that confirmed it (Douglass, 2000; Shin and Timberlake, 2000; Ng and Hills, 2003) and also studies focusing on individual world cities: Hong Kong (Wang and Cheng, 2010), Shanghai (Yusuf and Wu, 2002), Tokyo (Saito and Thornley, 2003), Seoul (Shin and Timberlake, 2006) and Taipei (Wang, 2003). Smith and Timberlake (2001) and Derudder et al. (2010) showed how connections between world cities changed over time.

3. Analyses of international air traffic flows

3.1. Model

A gravity model is employed to analyze international air traffic flows in this paper. The model is frequently used to determine the spatial orders or organization of air passenger and cargo flows (Harvey, 1951; Taaffe, 1962; Long, 1970; Wojahn, 2001; Grosche et al., 2007; Hwang and Shiao, 2011). The approach adopted here is a development of that used by Matsumoto (2004, 2007). These previous studies examined international air passenger and cargo flows within and among the Asian, European and American regions from the standpoint of global urban hierarchies and revealed the hub status of major cities worldwide for the period from 1982 to 1998 and to 2000, respectively. The results for Asia confirmed that Tokyo, Hong Kong and Singapore were positioned as key international air traffic hubs, and found that Hong Kong and Seoul experienced an extreme rise in their hub effects. Matsumoto et al. (2016) explored international air traffic connections, including business connectivity, alongside GDP per head, population and distance, into the model. The choice for using a gravity model for our goal could be justified because of the data availability and applicability on this scale and scope.

The present paper develops Matsumoto (2004, 2007) by: (1) focusing on East and Southeast Asia, which has experienced the most intense airport competition in the world. The significant growth of Chinese cities since 2000 will be embedded in the analyses; (2) using the extended data-set up to 2012. These studies haven't captured the effects of new international airports and integrator's hubs on the mobility of cities in a region's urban hierarchy after 2000. The changes in importance of the second ranked cities in terms of air transport will also be traced. Another improvement on data is the inclusion of much more observations of city-pairs; and (3) incorporating into the analyses all international air traffic flows from, to and within East and Southeast Asia. The previous studies analyzed international air traffic flows within and among regions separately. This change leads to the inclusion of international air traffic flows from/to East and Southeast Asia to/from other

regions than Europe and America (the Middle East, Africa etc.).

The dependent variables are international air passenger and cargo flows between cities on the segment level (T). The explanatory variables include GDP per head (G), population (P) and distance (D). In addition, city-dummy variables (C) are embedded into the model to examine the hub status of cities (see Table 1 for a listing). The entry rule for introducing them is their rank as a global city classified above gamma minus by GaWC (2012) in this region (see Appendix A for the classification of cities in Asia by GaWC (2012)). Ho Chi Minh City, Hanoi, Shenzhen and Tianjin are exempt from this rule because no data on international air traffic flows has been reported. This makes a list of thirteen cities for this variable. We give a number of ‘e’ to city-dummy variables when either or both of cities in a city-pair correspond to one of these thirteen cities, so 0 value is given if neither are among them. The size of ‘e’ raised to the power of a city-dummy parameter gives an indication of its hub status, as it accounts for passenger or cargo movements above those accounted for by GDP per head, population and distance. For example, an effect of transferring passengers is included in this value. If one flies from Osaka to Ulan Bator via Seoul, two tickets are issued: Osaka to Seoul and Seoul to Ulan Bator. In this case, Seoul functions as the hub airport, and thus the value for Seoul becomes larger.

The structure of the model is as follows:

$$T_{ij} = A \frac{(G_i G_j)^\alpha (P_i P_j)^\beta \exp(\delta C_1) \exp(\epsilon C_2) \exp(\zeta C_3) \cdots \exp(\xi C_{11}) \exp(o C_{12}) \exp(\pi C_{13})}{(D_{ij})^\gamma} \quad (1)$$

After transforming Eq. (1) into log form, ordinary least-squares (OLS) regression analysis is used.

Table 1

City-dummy variables.

C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	C ₇
Hong Kong	Singapore	Shanghai	Tokyo	Beijing	Kuala Lumpur	Seoul
C ₈	C ₉	C ₁₀	C ₁₁	C ₁₂	C ₁₃	
Jakarta	Bangkok	Taipei	Guangzhou	Manila	Osaka	

3.2. Data

The data on international air traffic flows between cities was obtained from the International Civil Aviation Organization (ICAO). Given that the applicable data is available from 1982 to

2012, the analyses were made over this period. Note that the ICAO data on international air cargo flows doesn't separate integrator cargo from belly cargo, but sums them up together. City-pairs selected were those that had international air traffic flows exceeding ten thousand passengers and one hundred tons of cargoes. Since cities were the basic unit of analysis, airport numbers were aggregated in cities that had multiple international airports. The data on GDP per head was taken from the World Bank (WB), the Organization for Economic Co-operation and Development (OECD), the United Nations (UN) and the International Monetary Fund (IMF), which was converted to US dollar at 2005 prices. With regard to the population data taken from the UN, the concept of an urban agglomeration, rather than that of a city proper, was used since the former was considered to be a better reflection of population served by an airport. The distance between cities was calculated by using the website: Great Circle Mapper.

The descriptive statistics of our data and its sources are displayed in Table 2 and in Table 3, respectively.

Table 2
Descriptive statistics.

	Passenger				Cargo			
	Maximum	Minimum	Mean	S.D.	Maximum	Minimum	Mean	S.D.
GDP per head	65,617.00	267.00	16,902.76	17,224.76	77,971.00	267.00	18,094.40	17,931.18
Population	37,438.34	22.00	4,149.36	5,348.06	37,438.34	70.00	4,713.17	5,526.83
Distance	17,577	125	4,725.64	3,545.72	17,577	136	5,445.70	3,747.11
Hong Kong		79				92		
Singapore		80				79		
Shanghai		57				46		
Tokyo		54				54		
Beijing		63				62		
Kuala Lumpur		52				48		
Seoul		82				75		
Jakarta		14				12		
Bangkok		73				74		
Taipei		13				17		
Guangzhou		39				33		
Manila		27				26		
Osaka		30				31		

Notes: Population is in thousands. As for cities, the number of city-pairs given 'e' value is indicated.

Table 3

Data sources.

Data	Sources
International air traffic flows between cities	On-flight Origin and Destination, International Civil Aviation Organization (ICAO)
Real GDP per head	World Bank National Accounts Data, World Bank (WB) OECD National Accounts Data Files, Organization for Economic Co-operation and Development (OECD) Statistical Yearbook, Fifty-sixth Issue, United Nations (UN) World Economic Outlook Database (April 2014), International Monetary Fund (IMF)
Population of urban agglomeration	World Urbanization Prospects (The 2011 Revision), United Nations (UN) Demographic Yearbook (1982-2012), United Nations (UN)
Distance between cities	Great Circle Mapper (http://www.gcmap.com/)

The focus of attention is East and Southeast Asia. Following the definition by the UN, East Asia is defined as China, Japan, Democratic People's Republic of Korea, Mongolia, Republic of Korea and Taiwan province of China. Southeast Asia includes Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste and Viet Nam. This area has been selected as it incorporates most of the nations that have been analyzed in studies of Asian economic development, which is best seen in the study of East Asian Miracle (The World Bank 1993) and the debates surrounding the work of Wade (1990). Considerable research on air transport in the region (Duval, 2014; Findlay et al., 1997; Bowen and Leinbach, 1995) provides a rich heritage that justifies the use of this regional definition. The basic data is all international air traffic flows from, to and within this region.

3.3. Results

3.3.1. Regression results for 2012

Table 4 shows the regression results for 2012. The overall model fit is relatively good and the estimated values of parameters for each variable are significant at the 1% level, except for distance, Osaka and Jakarta in the passenger specification and Osaka and Jakarta in the cargo specification. Jakarta is significant at the 5% level in both specifications.

The estimated values of parameters for the GDP and population variables in the cargo specification are larger than those in the passenger specification. This could confirm the globalization of plant location and the developing vertical division of labor in East and Southeast Asia. In this region, international air-freight transportation plays a significant role in reverse imports and intermediate goods exports among nations. For example, intermediate goods in high-tech industries are exported from developed countries, such as Japan, Korea or

Taiwan, to developing countries, like China, Vietnam or Myanmar, and finished goods are imported in the reverse direction. Meanwhile, the estimated value of distance parameter for passenger is larger than that for cargo, indicating that passengers are more sensitive to the length of their journey. These values in both models are relatively small, even having a counter intuitive sign for cargo. This means that demand for international air cargo transport is expected to be higher for cities that are farther to each other. This could be definitely because three global air-freight integrators have developed their hub-and-spoke systems (HSS), with their hubs well-clustered in Asia (Bowen, 2012).

Table 4
Regression results for 2012.

		Passenger		Cargo	
Constant	lnA	5.55	(8.26**)	-4.97	(-4.21**)
GDP	α	0.17	(6.31**)	0.34	(7.50**)
Population	β	0.13	(4.34**)	0.21	(4.33**)
Distance	γ	0.04	(0.86)	-0.22	(-3.00**)
Hong Kong	δ	1.52 [4.57]	(10.82**)	1.94 [6.99]	(8.77**)
Singapore	ϵ	1.03 [2.80]	(7.49**)	1.24 [3.46]	(5.58**)
Shanghai	ζ	0.95 [2.58]	(6.20**)	2.00 [7.42]	(7.71**)
Tokyo	η	0.86 [2.36]	(4.69**)	0.90 [2.45]	(3.06**)
Beijing	θ	0.89 [2.42]	(5.94**)	0.99 [2.70]	(4.11**)
Kuala Lumpur	ι	1.42 [4.14]	(9.97**)	1.95 [7.01]	(8.20**)
Seoul	κ	1.21 [3.34]	(8.36**)	1.50 [4.49]	(6.17**)
Jakarta	λ	0.49 [1.64]	(1.97*)	0.99 [2.70]	(2.39*)
Bangkok	μ	1.65 [5.23]	(12.11**)	2.33 [10.30]	(10.54**)
Taipei	ν	1.03 [2.80]	(3.97**)	1.30 [3.67]	(3.59**)
Guangzhou	ξ	0.89 [2.43]	(5.33**)	1.14 [3.13]	(4.06**)
Manila	\omicron	1.04 [2.83]	(5.51**)	0.81 [2.26]	(2.71**)
Osaka	π	0.30 [1.34]	(1.51)	0.09 [1.09]	(0.28)
Adj.R ²		0.58		0.48	
No. of Observation		678		628	

Notes: ** and * indicate significance at the 1% and the 5% levels, respectively. Figures in parentheses are ‘e’ raised to the power of city-dummy parameters.

Statistics involving ‘e’ raised to the power of city-dummy parameters for passenger reveal the highest hub status of Bangkok, Hong Kong, Kuala Lumpur and Seoul. These four cities opened a new international airport in the last twenty years and have had international passenger or cargo movements above those accounted for by GDP per head, population and

distance. Manila, Taipei, Singapore, three cities in Mainland China (Beijing, Shanghai and Guangzhou) and Tokyo show a high hub status. Regarding the city-dummy variables for cargo, Bangkok, Shanghai, Kuala Lumpur and Hong Kong show the highest hub status, while Seoul, Taipei, Singapore and Guangzhou show a high hub status. Three global air-freight integrators have expanded their intra-Asian hub-and-spoke networks and constructed a main hub and several regional hubs in many of these cities. For example, Hong Kong is a main hub (Central Asia Hub) of DHL. Their main regional hubs in this region include Bangkok, Shanghai and Singapore. Seoul and Taipei are positioned as their gateway hubs. FedEx moved its main hub (Asia-Pacific Regional Hub) from Subic Bay in the Philippines to Guangzhou in 2009. It opened its South Pacific Regional Hub in Singapore in 2012 and North Pacific Regional Hub in Osaka in 2014, among others. UPS relocated its main hub (Intra-Asia Hub) from Clark in the Philippines to Shenzhen in 2010. It has two other Air Hubs in this region: Hong Kong and Shanghai. Thus, Hong Kong and Singapore are given a hub role of all three integrators.

3.3.2. Temporal changes of parameters from 1982 to 2012

To examine the temporal changes in the values of parameters, the same analysis was applied to international air traffic flows in each year from 1982 to 2011. This will elucidate the changing importance of each explanatory variable in explaining international air traffic flows. The results are separately shown in Fig. 1 for passenger and in Fig. 2 for cargo, according to the rank of cities by GaWC (2012), with each value divided by that for 1982. As for the city-dummy variables, they are the temporal changes on the size of 'e' raised to the power of the estimated values of parameters.

As a whole, the GDP parameters became larger over the years analyzed, although that for passenger declined after hitting the peak in 2001, as seen in Fig. 1 (1) and Fig. 2 (1). The rises in the GDP parameter could show that international air traffic demand becomes larger in accordance with economic growth, while the decline after 2001 for passenger will imply the decreasing importance of GDP variable as a driver for international air passenger flows as a result of a reduction in the differences of economic power across the Asian countries. As for the population parameter in the passenger model, it was on the upward path with a decline in the last five years caused by the economic recession. This could confirm that low airfares provided by low-cost carriers (LCCs) using smaller long-haul aircrafts induce potential passengers to travel by air in heavily populated cities. In the cargo model, the population parameter gradually became smaller over this period, probably because of the structural changes of vertical division of labor across the Asian countries. During this period, intermediate goods have become exported or imported among developing or newly

industrializing countries which achieved a certain economic level. Insofar as the distance parameters are concerned, the analysis shows that its influence declined over the period analyzed, indicating that international air passengers and cargoes move with less and less regard to their journey length. That may also reflect a growing complexity in connectivity in the region, where longer length connections have an importance. That change will have some implications for the development of HSS in this region, as some hubs may be over-flown by longer-haul flights. That trend may also be linked to the technological innovation of aircrafts in the flight time in hours, which has allowed more point-to-point services on intra-regional routes, resulting in more direct city-to-city services within the region.

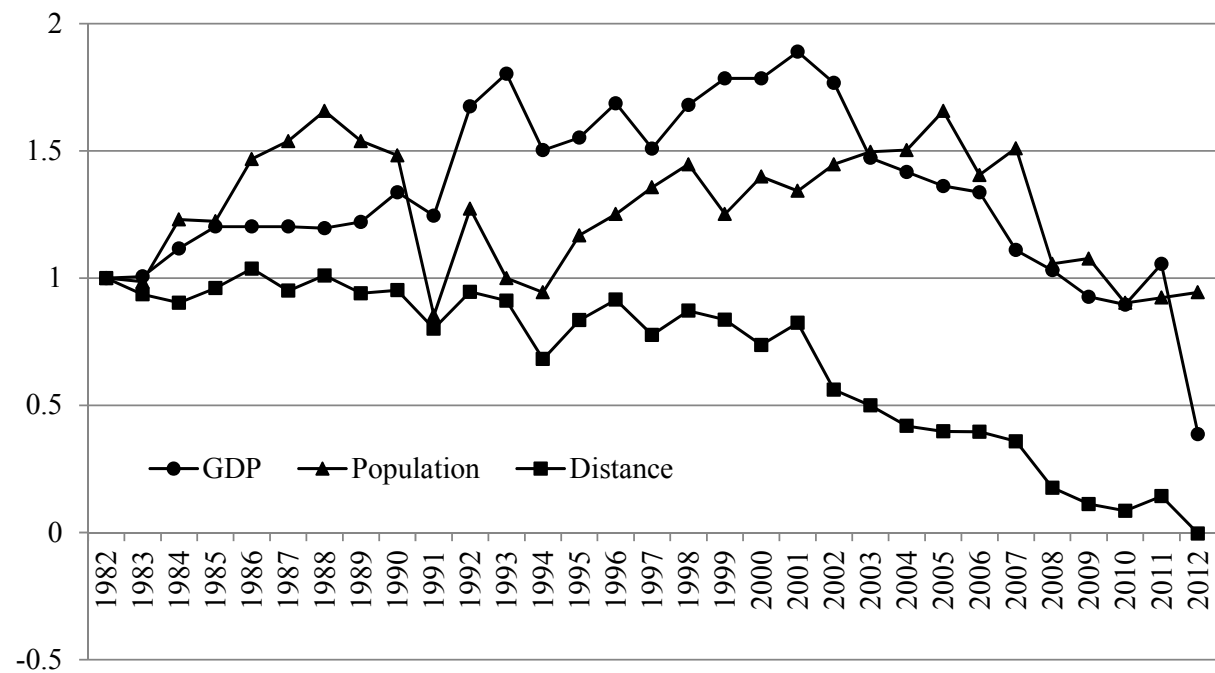
Looking at the effectiveness of the model in groups of cities, it seems outcomes in Shanghai and Beijing among cities in the larger Alpha class (Fig. 1 (2) and Fig. 2 (2)) have become much more predominant, confirming that these two cities play a prominent role in the network of cities in this region. Hong Kong's particular significance is also confirmed here, consistent with the conclusions drawn by Taylor and Derudder (2016) which was exploring its position in the global hierarchy.

In contrast, the experience is very uneven among cities in the smaller Alpha class (Fig. 1 (3) and Fig. 2 (3)). Some are establishing a stronger presence in the network of cities, while others are losing their influence. The analysis shows the increased importance of three capital cities in ASEAN (Kuala Lumpur, Bangkok and Jakarta), an outcome undoubtedly linked to the strong economic growth and economic integration at the regional level, along with the effects of new international airports and integrator's hubs.

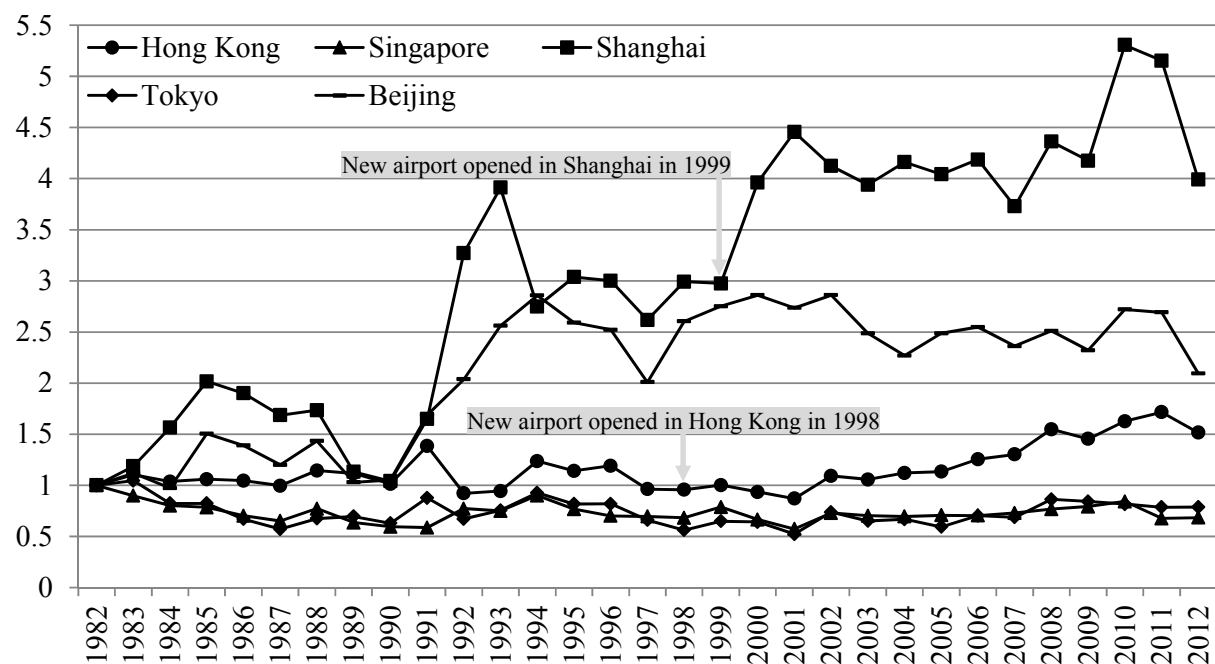
Among the cities in the Beta and Gamma classes seen in Fig. 1 (4) and Fig. 2 (4), the model's estimates indicate the prominent presence for Guangzhou. The big gain for this city probably reflects the strength of the Chinese economy, along with its new international airport which opened in 2004. As for cargo, the change may be also due to the hub re-location of FedEx in 2009.

Matsumoto (2004, 2007) demonstrated that Tokyo, Hong Kong and Singapore were the three cores of international aviation in this region in 2000, and found that the air traffic role of Seoul and Hong Kong was growing at an extraordinary rate up to 2000. The results presented here, which have had the narrower focus just on East and Southeast Asia, show that three cities in Mainland China and second ranked cities, such as Kuala Lumpur, Bangkok and Seoul, have had the strongest gains after 2000. In contrast, the hub status of Tokyo became smaller over the years analyzed. Insofar as Singapore is concerned, the outcome was more consistent, confirming that the city retains a prominent role in the network of cities in this

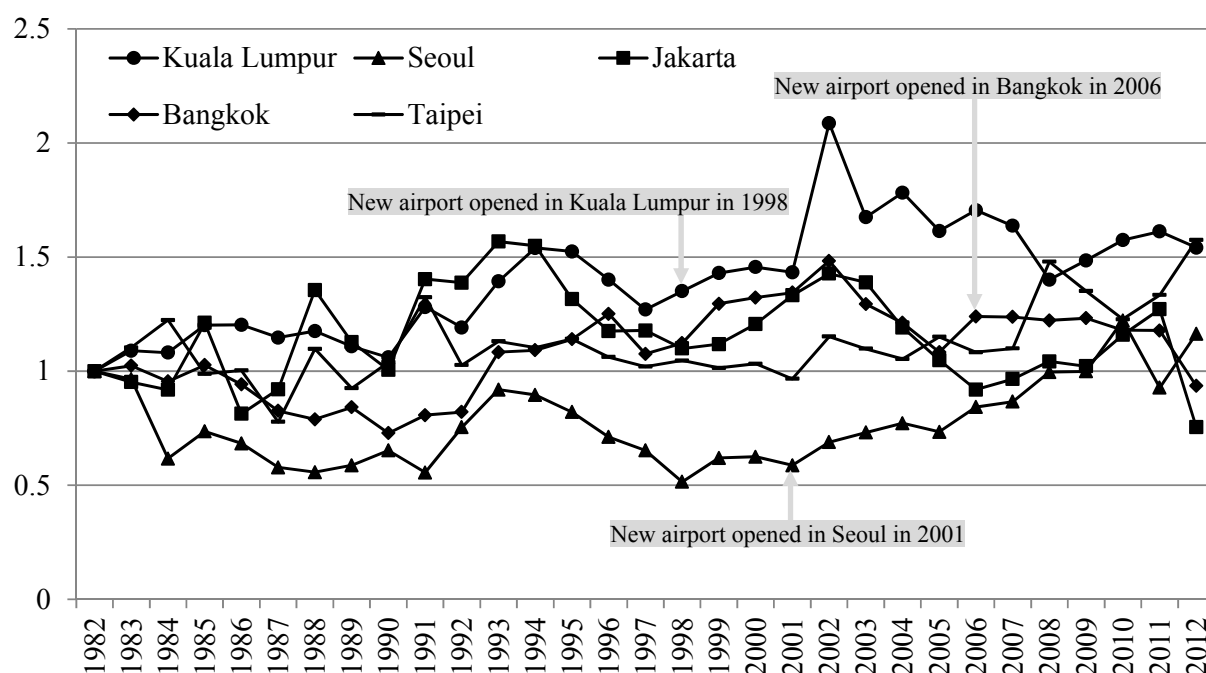
region. The results thus confirm the effects of new international airports and integrator's hubs on the hub status of cities and also on the mobility of cities in a region's urban hierarchy.



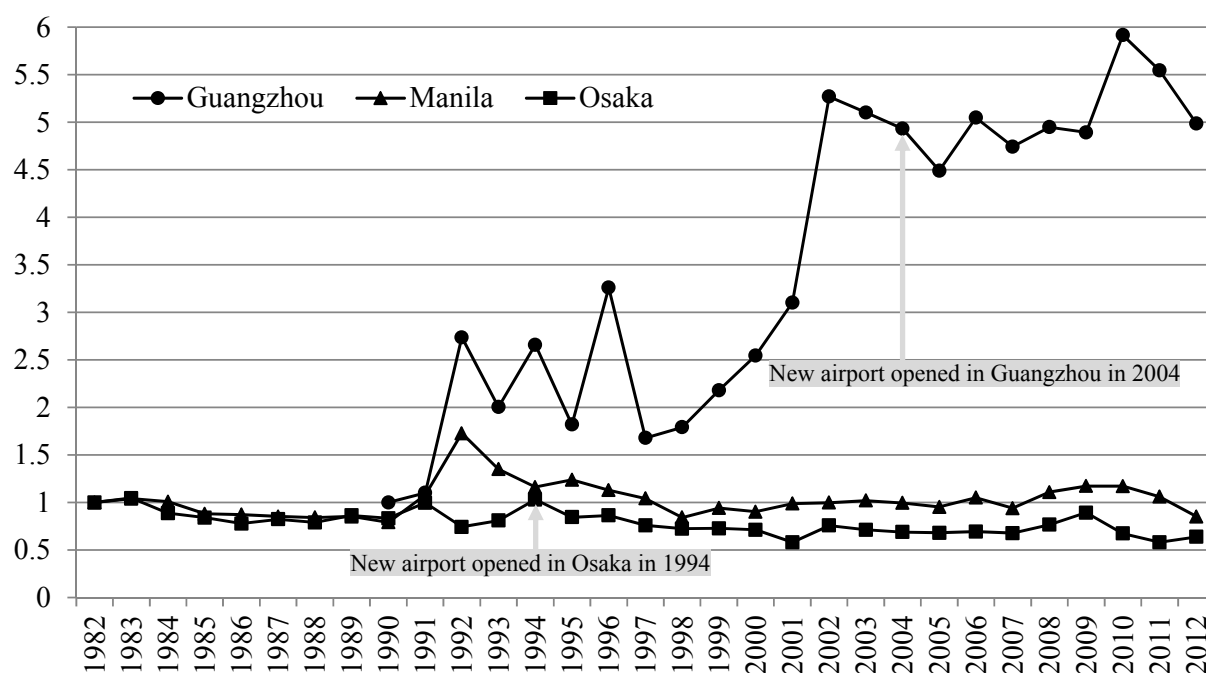
(1) The three basic variables.



(2) Alpha plus cities.



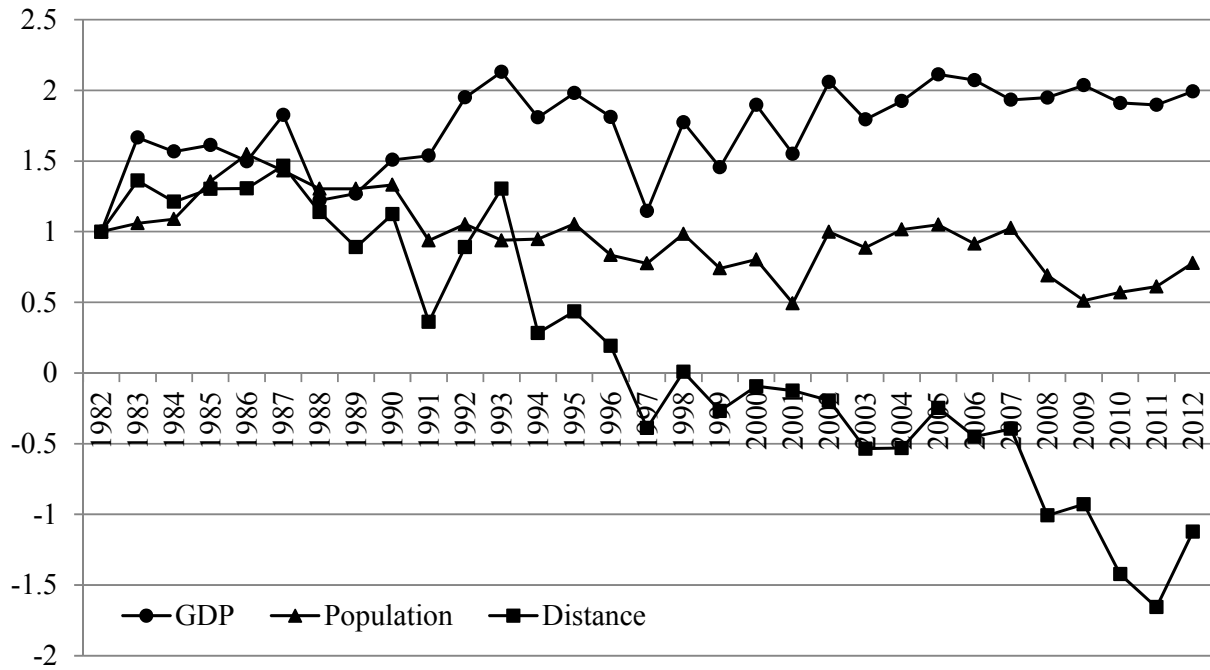
(3) Alpha and Alpha minus cities.



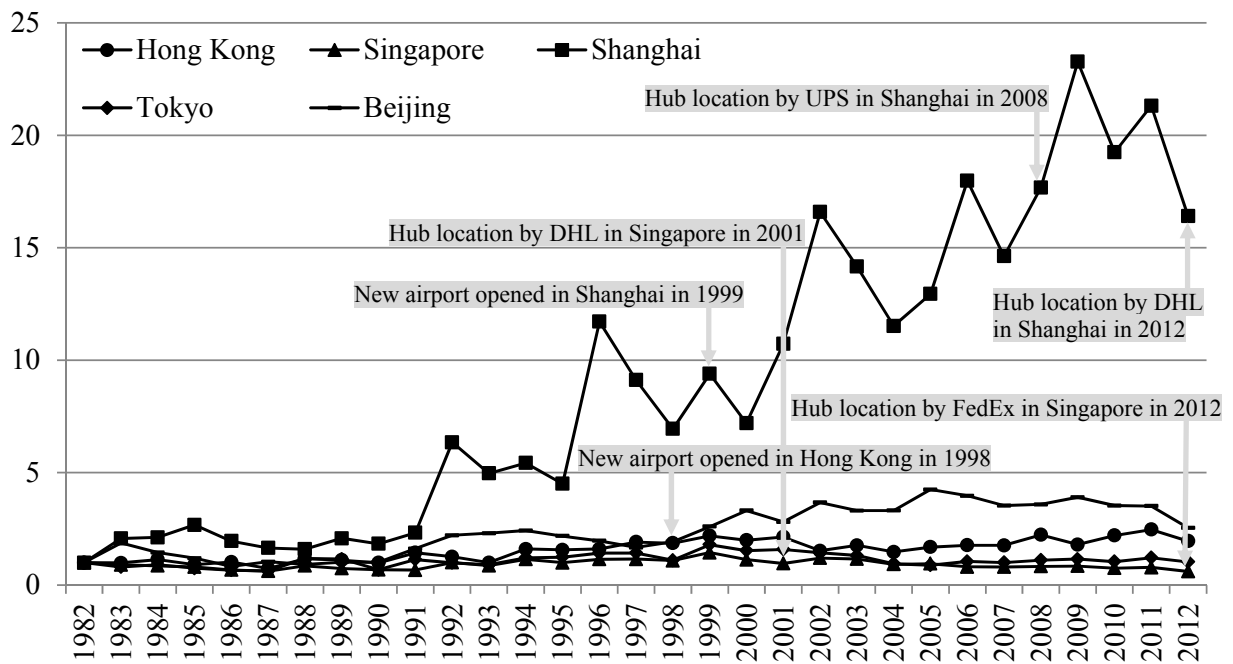
(4) Beta and Gamma cities.

Fig. 1. Parameter size relative to that in 1982 (passenger).

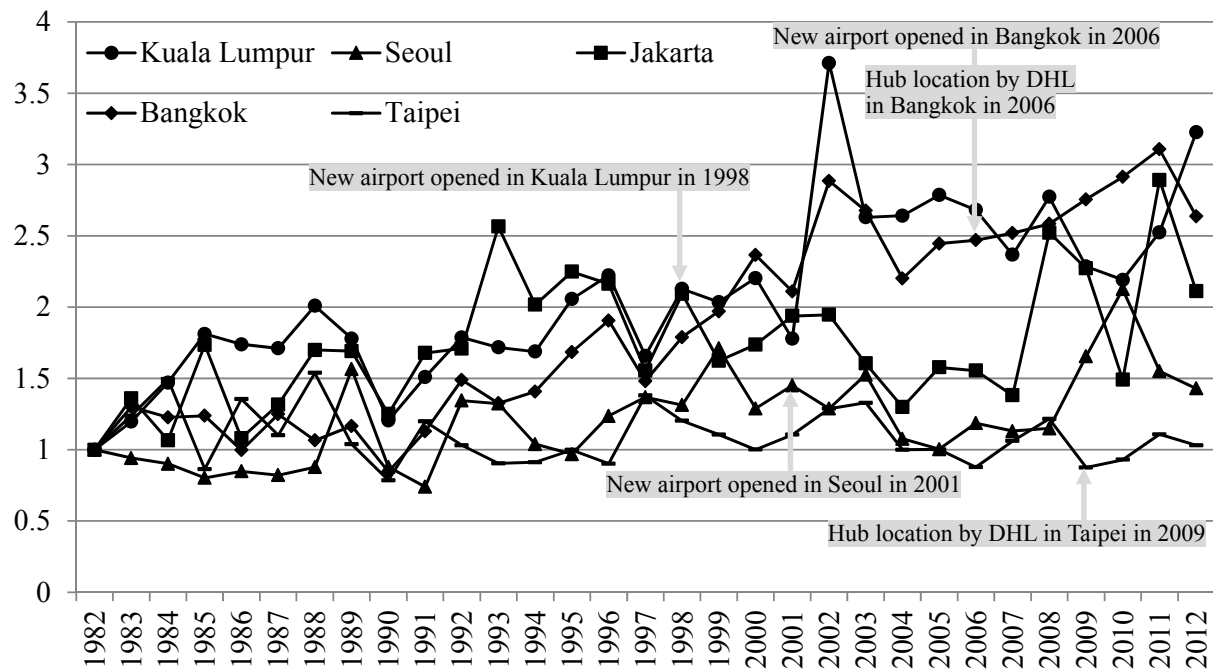
Note: As for Guangzhou, the initial year is 1990.



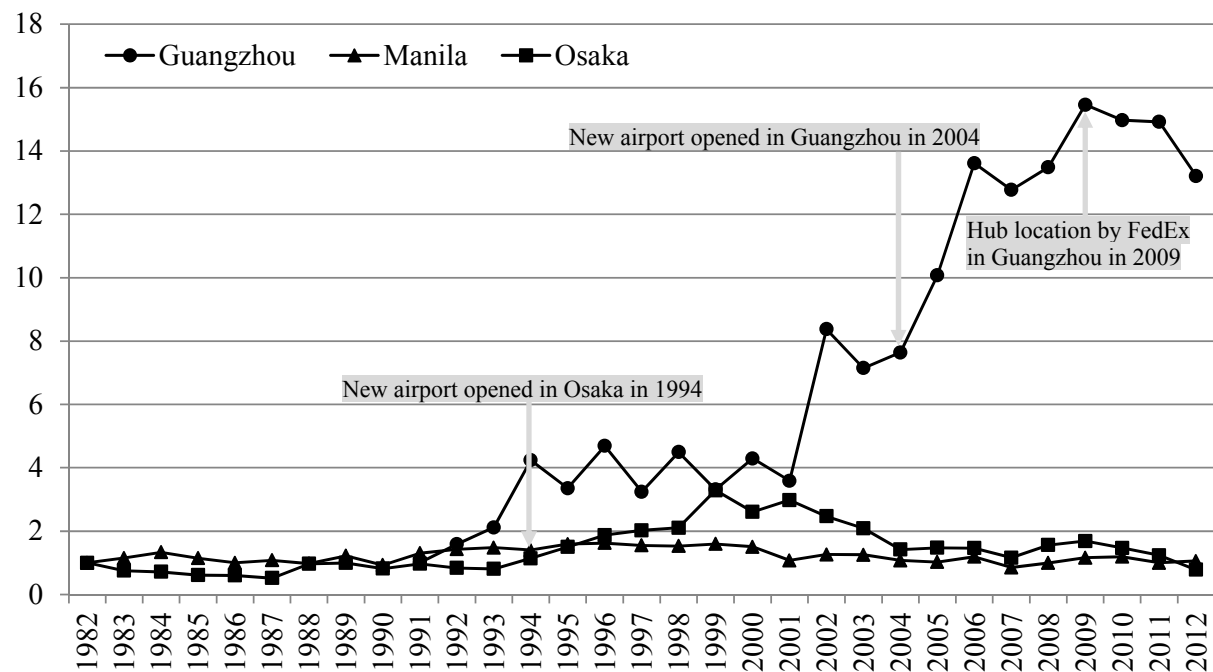
(1) The three basic variables.



(2) Alpha plus cities.



(3) Alpha and Alpha minus cities.



(4) Beta and Gamma cities.

Fig. 2. Parameter size relative to that in 1982 (cargo).

Note: As for Guangzhou, the initial year is 1991.

4. Discussion and conclusion

Until the 1990's, Tokyo had been positioned as one of the three global cities with London and New York in many studies (Sassen, 2001, see Beaverstock et al., 1999 for a listing of other references). In the recent project developed by GaWC, however, Tokyo has been classified in the second highest group out of twelve categories since 2000 with Hong Kong, Singapore, among others. Taylor and Derudder (2016) summarized that Hong Kong, not Tokyo, is consistently number three after London and New York, definitely gaining in importance and approaching the top level. They also pointed out that if current trends continue, the world city network will be dominated by a global cities triad: London, New York and Hong Kong, in the very near future. Although Tokyo still retains its historical legacy as the most important headquarter city (Taylor and Csomós, 2012), some multi-national firms moved their Asia-Pacific regional headquarters from Tokyo to Hong Kong or Singapore. This region is thus the most drastic in the mobility of cities in global urban hierarchies.

The work presented here captures the dynamic change of air transport city hierarchy within East and Southeast Asia, where the construction of new international airports and the location of integrator's hubs, along with the intense economic development, have changed the relative rank of a number of cities, providing a stronger role for a number of second ranked cities, positioned below the top ranked global cities. Shanghai, Guangzhou, Bangkok, Kuala Lumpur and Seoul are strengthening their competitive positions as international air transportation hubs definitely by the starting-up of a new international airport in the last decades. Three cities in Mainland China showed an extreme upward path in the mobility of cities in urban hierarchies in terms of international air traffic flows, along with Hong Kong.

In contrast, Tokyo, which had held the supremacy with Hong Kong and Singapore, is downgraded from a top ranked global city during the period analyzed. It is partly because Narita, one of the international airports in Tokyo Area, is relatively small, compared with other hub airports in Asia (De Wit et al., 2009; Burghouwt et al., 2009), and faces capacity shortage with limited opportunity to expand. The Japanese government decided the resumption of international air services at Haneda, which was practically downgraded to a domestic airport with the completion of Narita. The international role of Haneda expanded significantly after 2010, when an additional new runway was completed. The Japanese government intends to expand its role further to retrieve the competitive position Japan once had as a key traffic hub for international air transport in Asia. Lieshout and Matsumoto (2012) and Matsumoto and Lieshout (2014) showed that Haneda's market shares have been significantly rising in the connecting markets from Japan. Thus, the competitive position of Tokyo could be expected to become prominent again in the near future.

This research has shown that incorporating a measure of hub effect into an established model confirms the importance of this aspect of cities outside their basic factors of GDP, population and distance. It has also indicated that city-dummy variables are the most powerful in the model in explaining international air traffic flows, showing that decisions associated with the construction of new international airports and the location of integrator's hubs have a major influence on the city air transport activity hierarchy.

It is important to recognize that these results have a narrow foundation, relying on a simple distance measure. Refinement of the approach will need to incorporate more sensitive cost-related variables, such as fuel price or airfares charged, as the use of physical distance alone is probably now a crude measure of the actual interactions between cities. With respect to airfares, the research needs to incorporate LCC activity. Recent research by Bowen (2016) showed that LCCs are becoming major players in Southeast Asia. Although much LCC activity is focused on domestic markets, these carriers are extending links across Southeast Asia and increasingly into North Asia. As they grow, they will influence the role of their home based cities, notably three capital cities in ASEAN. The effect of LCCs on the mobility of cities in a region's urban hierarchy remains to be investigated in a further extension of this research.

A final consideration relates to the impact of domestic air traffic on the hierarchy of cities, something that has been outside the agenda of this paper. This is important as domestic markets are much larger than the international links analyzed here, as is well illustrated in maps of the busiest routes in each category in O'Connor and Fuellhart (2014). Hence, the scale of the domestic market served from a city could also be considered as an extension of this research.

Appendix

As outlined in Taylor and Derudder (2016), the data source in Globalization and World Cities Research Network (GaWC) is based on the connections between the offices of 175 advanced producer service (APS) firms in finance, banking, accountancy, insurance, law, consultancy or advertising across 526 cities. Measures of the number and the importance of firm offices in each city are compressed into a score, which is then used to rank and classify the cities. Five groups are identified: Alpha, Beta, Gamma, High sufficiency and Sufficiency. Alpha, Beta and Gamma cities are again sub-divided into three or four categories. Table A.1 shows the classification of cities in East and Southeast Asia by GaWC (2012).

Table A.1

Classification of cities in East and Southeast Asia by GaWC (2012).

GaWC category	Cities in rank order
Alpha+	Hong Kong, Singapore, Shanghai, Tokyo, Beijing
Alpha	Kuala Lumpur
Alpha-	Seoul, Jakarta, Bangkok, Taipei
Beta+	Guangzhou, Manila
Beta	Ho Chi Minh City
Beta-	Hanoi, Shenzhen
Gamma+	Osaka
Gamma	—
Gamma-	Tianjin
High sufficiency	Chengdu, Qingdao, Hangzhou, Nanjing, Chongqing
Sufficiency	Nagoya, Dalian, Kaohsiung, Xiamen, Penang, Surabaya, Phnom Penh, Wuhan, Busan, Johor Bahru, Xi'An, Macau, Fukuoka, Cebu, Labuan

Source: The World According to GaWC (<http://www.lboro.ac.uk/gawc/gawcworlds.html>).

Acknowledgements

The authors would like to express their sincere gratitude to the editor and two anonymous reviewers who provided valuable comments and suggestions on an earlier version of this paper. However, any remaining errors are the sole responsibility of the authors. This research was subsidized by the Japan Society for the Promotion of Science (JSPS), Grant-in-Aid for Scientific Research (C) (Grant Number: 17K03688), Grant-in-Aid for JSPS Fellows (Grant Number: 16J01007) and Grant-in-Aid for Scientific Research (B) (Grant Number: 17H02039).

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Highlights

1. New airports have significant effect on the cities' mobility in urban hierarchies.
2. Cities with integrators' hubs are strengthening their positions as air cargo hubs.
3. Hong Kong has now a leading position in the East/Southeast Asian air transport.
4. Tokyo has been downgraded from a top ranked global city.
5. Second ranked cities are now more prominent in the region's urban hierarchies.