Business connectivity, air transport and the urban hierarchy: A case study in East Asia

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Abstract:

This paper explores the effect of business connectivity between cities on their air traffic connections, and in turn on their place in a region's urban hierarchy. Its focus of attention is East Asia, where economic development is underpinned by a complex set of international flows of trade and investment. Business connectivity is a key part of these flows. The research incorporates a measure of business connections in a regression model that previously relied on GDP per head and population to account for international air links. Results confirm that business connectivity is a more important influence on the level of international air links within East Asia, and plays a major role in explaining the changes in city rank over time. The paper concludes with suggestions that possible incorporation of domestic air travel (itself larger than the intra-regional flows in this region) could enrich the insight of this approach.

Key Words:

International air links; Business connectivity; Urban hierarchy; Gravity model and East Asia

1. Introduction

Asia now stands as the largest aviation market on the globe. That position is underpinned by an intensive network of connections within the region, which is an outcome of an economic development experience that has bound together the countries and cities with flows of investment, trade and tourism. This process has lifted incomes and, as a result, has been felt in increases in air travel. However, those increases have also been shaped by the business linkages that initiate and manage the intra-regional trade and investment links. This effect has been especially intense in the long corridor along the eastern edge of Asia, stretching from Japan in the north to Indonesia and Thailand in the south. The current paper develops insight on this perspective by focusing attention on the high-level business service connections of the region's cities. The core idea is that changes in a city's business connections lie behind changes in its rank in the air transport hierarchy in its region.

2. Air transport networks and city hierarchies

Air transport and economic development are strongly intertwined. Matsumoto (2004, 2007) illustrated the strength of that link by showing that GDP per head and population of a city were significant predictors of the level of inter-city air traffic within and between regions of the globe. To refine the way economic activity shapes the outcome for individual cities, we can draw on the substantial research that has connected business services, the location of multi-national firms and air transport (Taylor et al., 2002; Alderson et al., 2010; Derudder et al., 2013; Liu et al., 2013, 2014). Keeling (1995) provided an initial insight on the way hierarchies of global cities (in terms of international air traffic flows) closely matched the location of headquarters of multi-national firms. Sassen (2006) underpinned that empirical observation by showing the connections between the operations of multi-national firms and advanced business services together would influence air connections between cities. Liu et al. (2013) confirmed that insight, showing 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.

A connection between these perspectives is expressed in the study of Poole (2010), which showed the strong associations between international business travel (involving employees of business service firms) and trade flows. Van de Vijver et al. (2014) confirmed the strength of that connection in the Asia-Pacific region. The trade flows identified by Van de Vijver et al. (2014) have been integral to the development of Eastern Asia, as global manufacturing production systems emerged from around 1960 and trade within the region expanded rapidly (Ozawa, 2006; Athukorala and Hill, 2010). These flows began as Japanese corporations invested in South East Asian countries; their approach was followed by Korean and Taiwanese firms, and today there are multi-directional flows across the region, in particular, into and out of China. In a recent overview, the Ministry of Economy, Trade and Industry of Japan (2012) described the "international division of production" within the region, which is reflected in a trade structure where intermediary goods are exported within the region and final goods outside the region. The connectivity between firms in this "division of production" relies upon business services to initiate investment, manage production and arrange logistics. This activity stimulates air transport links as corporate management staff move between production locations (Ando and Kimura, 2010; Edgington and Hayter, 2013), just as supply chain links in electronics industry stimulated air cargo movements, as shown by Leinbach and Bowen (2004).

Recognizing the importance of connectivity between business services, along with the movement of management personnel, means that change in the scale of business service connections of a city is likely to play a critical role in its place in the regional air transport network. To date, much attention has been focused upon headquarter cities, which are significant clusters of business service firms and so play a prominent role in 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 the most upwardly mobile city between 1977 and 1995 was Hong Kong, and found 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 airline passenger movements began to favor a group of second ranked cities, positioned below the top ranked global cities; Asian examples included Seoul and Osaka. O'Connor and Fuellhart (2013) also found a shift in favor of a group of next largest cities, identifying Mumbai and Guangzhou, in particular. These changes in importance of the second ranked cities in terms of air transport could be traced to the engagement of their firms in the intra-Asian trade and investment flows, which in turn could be felt in a change in the character of their business service activities.

In analyzing air transport networks, it is important to consider the configuration of hubs used by airlines, a fundamental part of the operation of the airline industry. Hubs are usually located in major cities. A good illustration is the role that Seoul and Shanghai have played as a hub for inbound/outbound international traffic to/from Japan, as Lieshout and Matsumoto (2012) and Matsumoto and Lieshout (2014) have shown. That role has given these cities an even larger international presence than might be the case just in terms of their business services functions.

However, once again it is possible that there may be changes in hub roles as airlines shift toward mid-sized long-haul aircraft (initially the A330 and B777, now the A350 and B787), which are better suited to serving smaller cities (O'Connor and Fuellhart, 2015) and so 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, discussed above. This can be seen in the opening of new 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 (2006). At the same time, the big hubs added new 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. Hence, there has been a major re-alignment in airport capacity, providing the potential to change the hierarchical structure of hub cities.

Understanding the current air transport network in today's rapidly developing Asia calls for insight on the way the connectivity of business services and the arrangement of hub functions interact with the underlying pattern of GDP and population as influences on air transport activity. This paper provides a contribution by developing a regression model incorporating a city's business connectivity and hub functions as explanatory factors of its level of international air traffic. This will establish the strength of these two factors, in comparison with the broadly based influences of GDP per head and population. The analysis will be carried out for 2012 and over the period from 2000 to 2012. As a preliminary step, it will establish the strength of the intra-Asian dimension in the air traffic in one part of Asia.

3. International air passenger traffic in East Asia

3.1. Study area

The focus of attention is East Asia, which comprises the countries shown in Fig. 1. 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 figure also shows the seventeen cities with international airports for which a measure on business service connectivity is available, drawn from the GaWC analysis discussed in detail in Section 4.1. below (GaWC 2012). Two other key measures of air transport at these cities are included in Tables 1 and 2.

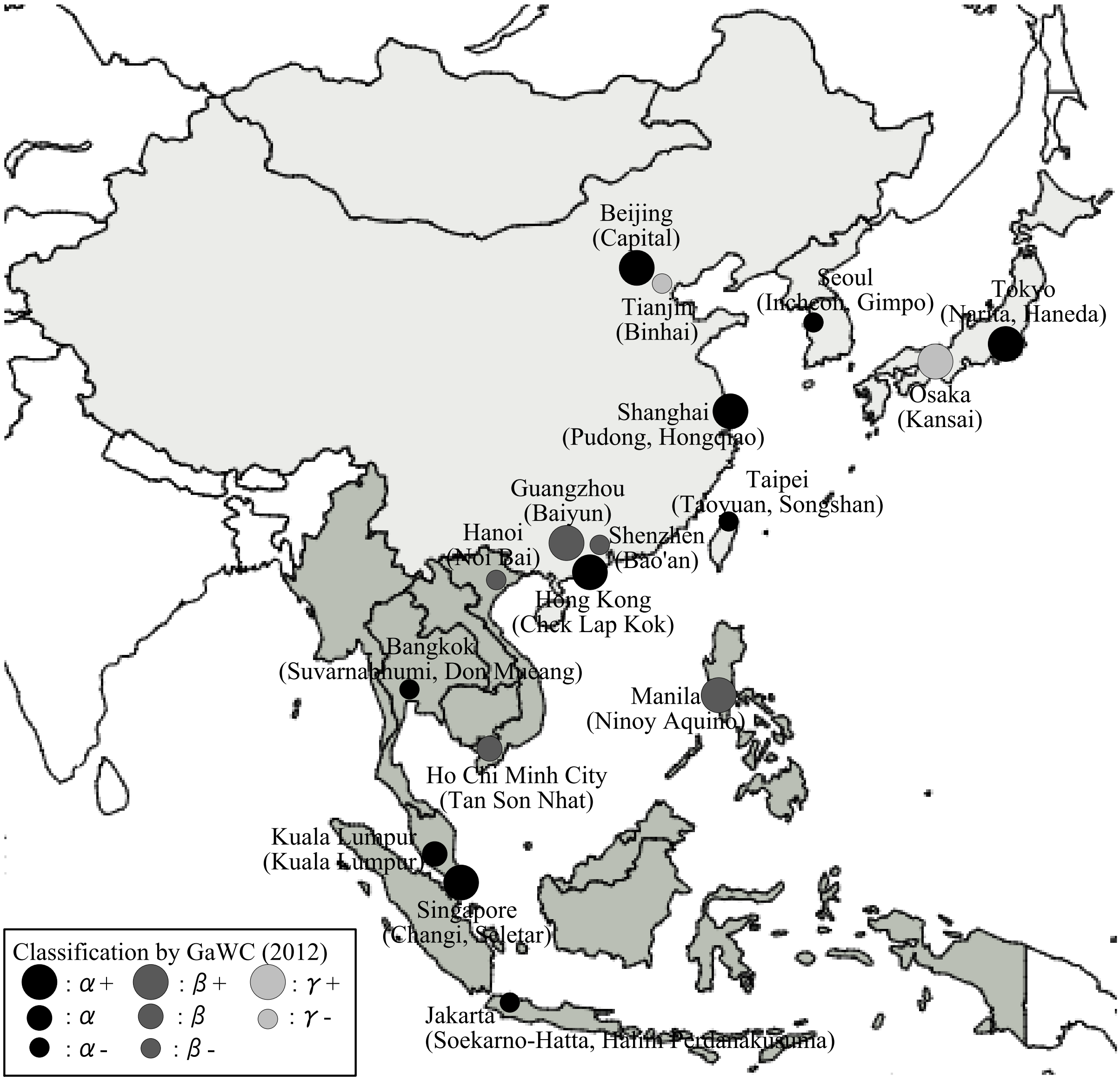


Fig. 1. Countries and primary cities with their international airports in East Asia.
Note: East Asia is defined as China, Japan, Democratic People's Republic of Korea, Mongolia, Republic of Korea, Taiwan province of China, ASEAN countries (Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam) and Timor-Leste.

3.2. International air passenger movements in cities

Table 1 shows the international air passenger movements of the seventeen cities in this region for 1982, 1997 and 2012. Among these cities, Shanghai, Tokyo, Bangkok, Seoul and Taipei have multiple international airports at present. In 2012, Hong Kong had the largest international air passenger movements (55,831 thousand). The second largest was Singapore (51,205 thousand), followed by Seoul (42,632 thousand), Bangkok (41,883 thousand) and

Tokyo (37,547 thousand). Compared with the rankings in 1982 and 1997, Seoul and Bangkok strikingly increased their role in international air passenger movements, along with Hong Kong.

Table 1
International air passenger movements at seventeen cities in East Asia.

City	GaWC (2012)	Airport	Airport code	1982	1997	2012
Beijing	Alpha+	Beijing Capital Int'l	PEK	n.a.	4,332	19,134
Hong Kong	Alpha+	Hong Kong Int'l	HKG	9,240	14,966	55,831
Shanghai	Alpha+	Shanghai Pudong Int'l	PVG	—	—	21,530
		Shanghai Hongqiao Int'l	SHA	n.a.	4,035	2,493
		Total		n.a.	4,035	24,023
Singapore	Alpha+	Singapore Changi	SIN	8,612	25,174	51,182
		Seletar	XSP	27	20	23
		Total		8,639	25,195	51,205
Tokyo	Alpha+	Narita Int'l	NRT	8,638	24,865	29,619
		Tokyo Int'l	HND	474	845	7,929
		Total		9,113	25,710	37,547
Kuala Lumpur	Alpha	Kuala Lumpur Int'l	KUL	2,592	8,761	27,986
Bangkok	Alpha-	Suvarnabhumi	BKK	—	—	40,708
		Don Mueang Int'l	DMK	6,192	18,762	1,175
		Total		6,192	18,762	41,883
Jakarta	Alpha-	Soekarno–Hatta Int'l	CGK	—	5,502	n.a.
		Halim Perdanakusuma	HLP	1,876	208	n.a.
		Total		1,876	5,709	n.a.
Seoul	Alpha-	Incheon Int'l	ICN	—	—	38,534
		Gimpo Int'l	GMP	2,734	15,233	4,097
		Total		2,734	15,233	42,632
Taipei	Alpha-	Taiwan Taoyuan Int'l	TPE	3,240	14,185	25,961
		Taipei Songshan	TSA	—	—	2,728
		Total		3,240	14,185	28,689
Guangzhou	Beta+	Guangzhou Baiyun Int'l	CAN	n.a.	370	8,299
Manila	Beta+	Ninoy Aquino Int'l	MNL	2,788	7,726	n.a.
Ho Chi Minh City	Beta	Tan Son Nhat Int'l	SGN	n.a.	n.a.	8,272
Hanoi	Beta-	Noi Bai Int'l	HAN	n.a.	n.a.	4,807
Shenzhen	Beta-	Shenzhen Bao'an Int'l	SZX	—	n.a.	1,366
Osaka	Gamma+	Kansai Int'l	KIX	—	11,508	11,253
		Osaka Int'l	ITM	3,237	—	—
		Total		3,237	11,508	11,253
Tianjin	Gamma-	Tianjin Binhai Int'l	TSN	n.a.	n.a.	823

Notes: Unit is thousand. n.a. means data is not available. —means the airport was not yet opened or had no international services.
Source: Compiled by authors from Airport Traffic, ICAO.

3.3. International air passenger flows between cities

Table 2 shows the top twenty city-pairs in international air passenger flows from, to and within East Asia for 1982, 1997 and 2012. It is apparent that international air passenger flows increased rapidly in the last thirty years, as cities in this region became densely connected with one another. In 2012, the Tokyo-Seoul route was ranked first with more than three million passengers, followed by the city-pairs of Hong Kong-Taipei, Hong Kong-Singapore, Hong Kong-Bangkok, Hong Kong-Shanghai and Singapore-Bangkok, all of which transported over two million passengers. Overall, Hong Kong, Singapore, Tokyo, Seoul and Bangkok were the main origins/destinations in this region, with Shanghai becoming another main center in 2012.

The low ranking of other global city links, especially in 2012, shows that the study area is a major international air passenger market in itself and global connectivity is not a main driver of a city's hub function, as shown by O'Connor and Fuellhart (2014).

Table 2
Top twenty city-pairs in international air passenger flows from, to and within East Asia.

1982			1997			2012		
1	Singapore-Kuala Lumpur	1,143	1	Singapore-Kuala Lumpur	2,493	1	Tokyo-Seoul	3,240
2	Hong Kong-Tokyo	1,016	2	Hong Kong-Taipei	2,343	2	Hong Kong-Taipei	2,846
3	Hong Kong-Bangkok	973	3	Tokyo-Honolulu	2,208	3	Hong Kong-Singapore	2,624
4	Hong Kong-Taipei	973	4	Tokyo-Seoul	2,038	4	Hong Kong-Bangkok	2,295
5	Tokyo-Honolulu	839	5	Hong Kong-Bangkok	1,964	5	Hong Kong-Shanghai	2,173
6	Tokyo-Seoul	710	6	Hong Kong-Tokyo	1,880	6	Singapore-Bangkok	2,015
7	Tokyo-Taipei	678	7	Singapore-Bangkok	1,600	7	Hong Kong-Manila	1,951
8	Hong Kong-Manila	637	8	Hong Kong-Singapore	1,440	8	Hong Kong-Seoul	1,802
9	Singapore-Jakarta	611	9	Singapore-Jakarta	1,342	9	Shanghai-Tokyo	1,780
10	Tokyo-Los Angeles	605	10	Tokyo-Los Angeles	1,328	10	Shanghai-Seoul	1,726
11	Hong Kong-Singapore	595	11	Hong Kong-Manila	1,245	11	Hong Kong-Tokyo	1,642
12	Singapore-Bangkok	580	12	Tokyo-Bangkok	1,222	12	Tokyo-Bangkok	1,571
13	Taipei-Osaka	504	13	Singapore-Tokyo	1,188	13	Beijing-Hong Kong	1,345
14	Hong Kong-Osaka	429	14	Seoul-Osaka	1,091	14	Seoul-Osaka	1,311
15	Osaka-Honolulu	413	15	Osaka-Honolulu	1,059	15	Singapore-Jakarta	1,305
16	Tokyo-Manila	389	16	Hong Kong-Seoul	1,041	16	Beijing-Seoul	1,267
17	Seoul-Osaka	363	17	Tokyo-Taipei	990	17	Singapore-Tokyo	1,202
18	Tokyo-San Francisco	318	18	Tokyo-London	970	18	Shanghai-Singapore	1,184
19	Tokyo-Guam	318	19	Tokyo-Guam	950	19	Singapore-London	1,183
20	Singapore-Penang	314	20	Tokyo-San Francisco	824	20	Singapore-Sydney	1,129

Notes: Unit is thousand. Colored city-pairs are intercontinental links.
Source: Compiled by authors from On-flight Origin and Destination, ICAO.

4. Analyzing international air traffic flows: data and model

4.1. Data

The basic data is all international air passenger flows from, to and within this region. That is consistent with a focus on globally-structured business service firms used in the GaWC analysis. In the Asian case, there is a problem in the case of Singapore and Hong Kong, which only have international traffic. However, given that there is little doubt these two cities play a major role in global business, the fact that their air traffic may seem overstated is unlikely to influence the interpretation of the results of our analysis.

We obtained international air traffic data from the International Civil Aviation Organization (ICAO). As addressed in Derudder and Witlox (2005a, 2005b, 2008), the relevance of research based on the international air traffic statistics of the ICAO is potentially undermined because these data will be imperfect in some cases. One possible weakness in this first data is reduced by utilizing both of On-flight Origin and Destination (OFOD) and Traffic by Flight Stage (TFS).

One other data weakness is that little traffic of Low-cost carriers (LCCs) in Asia is included in the ICAO data at the moment. Specifically, only four LCCs (Peach Aviation (2012) based in Osaka, Cebu Pacific (2009-2010) based in Manila, Jetstar Asia Airways (2008-2012) and Tigerair (2010-2012) both based in Singapore) reported their traffic data to the ICAO as of 2012, but their data skipped some years of their operation.

Even the traffic data on AirAsia group, Asia's largest LCC mainly based in Kuala Lumpur, Manila, Bangkok, Jakarta etc., came into the ICAO data for the first time in 2013, although it commenced its first international service in 2003. Other major LCCs in Asia, including Eastar Jet, Jeju Air, Jin Air and T'way Airlines all based in Seoul, Spring Airlines based in Shanghai and Nok Air based in Bangkok, are completely missing in the ICAO data at the moment.

City-pairs selected were those that had international air traffic flows exceeding ten thousand passengers. 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 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 measure of business services connectivity was obtained from GaWC (2012). As outlined in Taylor and Derudder (2016), this data source 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 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. This classification was used to create a variable for the model by assigning a number for each level in the classification: twelve for Alpha plus cities, eleven for Alpha cities, ten for Alpha minus cities, nine for Beta plus cities, eight for Beta cities, seven for Beta minus cities, six for Gamma plus cities, five for Gamma cities, four for Gamma minus cities, three for High sufficiency cities, two for Sufficiency cities and one for cities below Sufficiency with no classification.

Table 3 shows the classification of cities in East Asia by GaWC in 2000, 2004, 2008 and 2012. In this table, a variable is created by giving a number to each city.

Finally, the model utilized measures of GDP per head, population and distance. The data sources are displayed in Table 4.

Table 3

Classification of cities in East Asia by GaWC above Gamma minus and measure of business connections.

No.	City	Country	GaWC (2012)	Measure of business connections			
				2000	2004	2008	2012
1	Beijing	China	Alpha+	9	10	12	12
2	Hong Kong	China	Alpha+	12	12	12	12
3	Shanghai	China	Alpha+	10	10	12	12
4	Singapore	Singapore	Alpha+	12	12	12	12
5	Tokyo	Japan	Alpha+	12	12	12	12
6	Kuala Lumpur	Malaysia	Alpha	10	10	11	11
7	Bangkok	Thailand	Alpha-	10	10	10	10
8	Jakarta	Indonesia	Alpha-	10	10	10	10
9	Seoul	Korea	Alpha-	9	10	11	10
10	Taipei	Taiwan	Alpha-	10	10	10	10
11	Guangzhou	China	Beta+	4	4	7	9
12	Manila	Philippines	Beta+	9	6	9	9
13	Ho Chi Minh City	Vietnam	Beta	5	3	7	8
14	Hanoi	Vietnam	Beta-	3	3	3	7
15	Shenzhen	China	Beta-	2	2	5	7
16	Osaka	Japan	Gamma+	3	4	3	6
17	Tianjin	China	Gamma-	1	1	2	4

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

Table 4

Other data sources.

Data	Sources
International air passenger flows between cities	On-flight Origin and Destination, International Civil Aviation Organization (ICAO)
Real GDP per capita	World Bank National Accounts Data, World Bank (WB)
	OECD National Accounts Data Files, Organisation 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/)

4.2. Model

A gravity model is employed to analyze international air passenger 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) on global networks and Matsumoto (2007) on competition between Asian hubs. The development involves the inclusion of business connectivity alongside GDP per head, population and distance.

In addition, city-dummy variables are embedded into the model to examine the hub effect of cities. The entry rule for introducing them is their rank as a global city classified above gamma minus by GaWC (2012). The size of 'e' raised to the power of a city-dummy parameter gives an indication of its hub function, as it accounts for passenger movements above those accounted for by GDP per head, population, business connections and distance.

The structure of the model is as follows:

$$T_{ij} = A\frac{(G_iG_j)^{\alpha}(P_iP_j)^{\beta}(B_iB_j)^{\gamma}\exp(\varepsilon C_1)\exp(\zeta\varepsilon C_2)\exp(\eta C_3)\cdots\exp(\tau C_{15})\exp(\upsilon C_{16})\exp(\phi C_{17})}{(D_{ij})^{\delta}} \quad (1)$$

The dependent variable is international air passenger flows between cities (T). The explanatory variables include GDP (G), population (P), business connections (B) and distance (D). C is the city-dummy variables (see Table 5 for a listing) and A is the constant. After transforming Eq. (1) into log form, ordinary least-squares (OLS) regression analysis is used.

Table 5
City-dummy variables.

Dummy variable	C_1	C_2	C_3	C_4	C_5	C_6
City	Beijing	Hong Kong	Shanghai	Singapore	Tokyo	Kuala Lumpur
GaWC (2012)	Alpha+	Alpha+	Alpha+	Alpha+	Alpha+	Alpha
Dummy variable	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
City	Bangkok	Jakarta	Seoul	Taipei	Guangzhou	Manila
GaWC (2012)	Alpha-	Alpha-	Alpha-	Alpha-	Beta+	Beta+
Dummy variable	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	
City	Ho Chi Minh City	Hanoi	Shenzhen	Osaka	Tianjin	
GaWC (2012)	Beta	Beta-	Beta-	Gamma+	Gamma-	

4.3. Results

4.3.1. Regression results in 2012

Table 6 shows the regression results in 2012. The overall model fit is relatively good. The estimated value of parameter for the business connections variable is larger than GDP and population, indicating that business connections are the most powerful variable in this model in explaining international air passenger flows. Meanwhile, distance is a deterrent to air traffic flows in this region. Regarding the city-dummy variables, Ho Chi Minh City and Hanoi show a highest hub effect. These two Vietnamese cities are ranked in the Beta category in GaWC (2012). Bangkok and Seoul, positioned just below the top ranked global cities, also show a high hub effect. This suggests the second ranked cities in this region have had the strongest gains in terms of international air passenger flows, as discussed earlier. Cities that have always been seen as major hubs (Tokyo, Hong Kong and Singapore) have retained their absolute supremacy in the network. The results on city-dummy variables confirm the importance of this aspect of cities outside their basic factors of GDP, population, business connections and distance, showing that decisions associated with airline operations have a major influence on the city air transport activity hierarchy.

Table 6
Regression results for 2012.

Variable	GaWC (2012)		Unstandardized coefficients		Standardized coefficients	t-value	Sig.
			B	Std. error	β		
Constant		lnA	10.30	0.82		12.59**	0.00
GDP		α	0.07	0.03	0.12	2.65**	0.01
Population		β	0.00	0.03	0.00	-0.02	0.99
Distance		γ	0.25	0.05	-0.20	4.73**	0.00
Business connections		δ	0.40	0.06	0.45	7.27**	0.00
Beijing	Alpha+	ε	0.36 (1.44)	0.16	0.09	2.24*	0.03
Hong Kong	Alpha+	ζ	1.02 (**2.76**)	0.15	0.27	6.76**	0.00
Shanghai	Alpha+	η	0.50 (1.64)	0.16	0.12	3.09**	0.00
Singapore	Alpha+	θ	0.69 (1.99)	0.14	0.19	4.84**	0.00
Tokyo	Alpha+	ι	0.71 (**2.04**)	0.18	0.16	4.07**	0.00
Kuala Lumpur	Alpha	κ	0.62 (1.86)	0.17	0.14	3.66**	0.00
Bangkok	Alpha-	λ	1.02 (**2.77**)	0.16	0.27	6.51**	0.00
Jakarta	Alpha-	μ	-0.10 (0.90)	0.25	-0.01	-0.41	0.69
Seoul	Alpha-	ν	0.88 (**2.42**)	0.15	0.24	6.06**	0.00
Taipei	Alpha-	ξ	0.47 (1.59)	0.24	0.06	1.96*	0.05
Guangzhou	Beta+	ο	0.47 (1.59)	0.17	0.09	2.70**	0.01
Manila	Beta+	π	0.56 (1.75)	0.19	0.09	2.96**	0.00
Ho Chi Minh City	Beta	ρ	1.29 (**3.61**)	0.21	0.20	6.27**	0.00
Hanoi	Beta-	σ	1.18 (**3.26**)	0.21	0.19	5.75**	0.00
Shenzhen	Beta-	τ	-0.44 (0.64)	0.62	-0.02	-0.71	0.48
Osaka	Gamma+	υ	0.31 (1.36)	0.18	0.05	1.70	0.09
Tianjin	Gamma-	φ	-0.56 (0.57)	0.51	-0.03	-1.11	0.27
Adj.R^2					0.53		
Observations					727		

Note: Figures in parentheses are 'e' raised to the power of a city-dummy parameter.

4.3.2. Temporal changes of parameters from 2000 to 2012

To examine the temporal changes in the value of parameters, the same analysis was applied to the international air passenger flows in 2000, 2004 and 2008. This will elucidate the changing importance of each explanatory variable in explaining international air passenger flows. The results are separately shown in Fig. 2, according to the rank of cities by GaWC (2012), with each value divided by that for 2000. As for the city-dummy variables, they are the temporal change on the size of ‘e’ raised to the power of the estimated value of parameter.

As a whole, the influence of the GDP, population and distance parameters declined over the period analyzed, as seen in Fig. 2 (A). In contrast, the business connections variable has become much more prominent, confirming the fundamental role that the intra-regional connectivity between firms now plays as a dynamic influence upon air transport activity, even though its relative importance did decline since 2004.

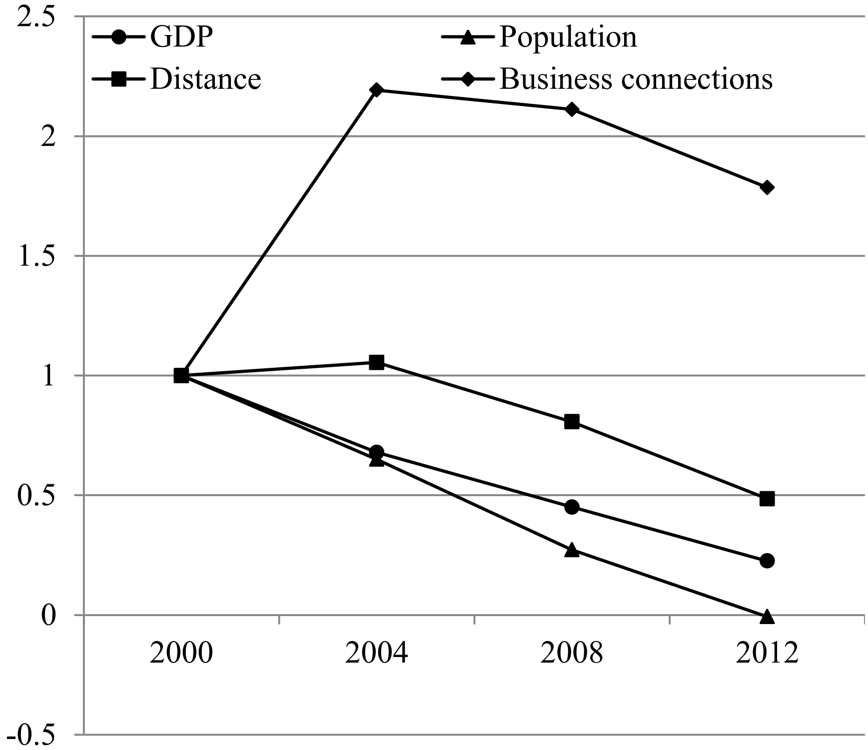
Insofar as the distance parameter is concerned, the analysis shows that international air passengers move with less and less regard to their journey length. That may also reflect a growing complexity in connectivity in the region, where longer length connections have an importance. That can be seen in the inclusion of long-haul links, such as Tokyo-Bangkok, Singapore-Tokyo and Shanghai-Singapore among the top twenty routes shown in Table 2 for 2012. That change will have some implications for the development of hub-and-spoke systems (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 aircraft discussed earlier, 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 among cities in the larger Alpha class (Fig. 2 (B)) were more consistent, confirming that this group of five cities retains a prominent role in the network of cities in this region. Hong Kong's particular significance is confirmed here, consistent with the conclusions drawn by Taylor and Derudder (2016) which was exploring its position in the global hierarchy.

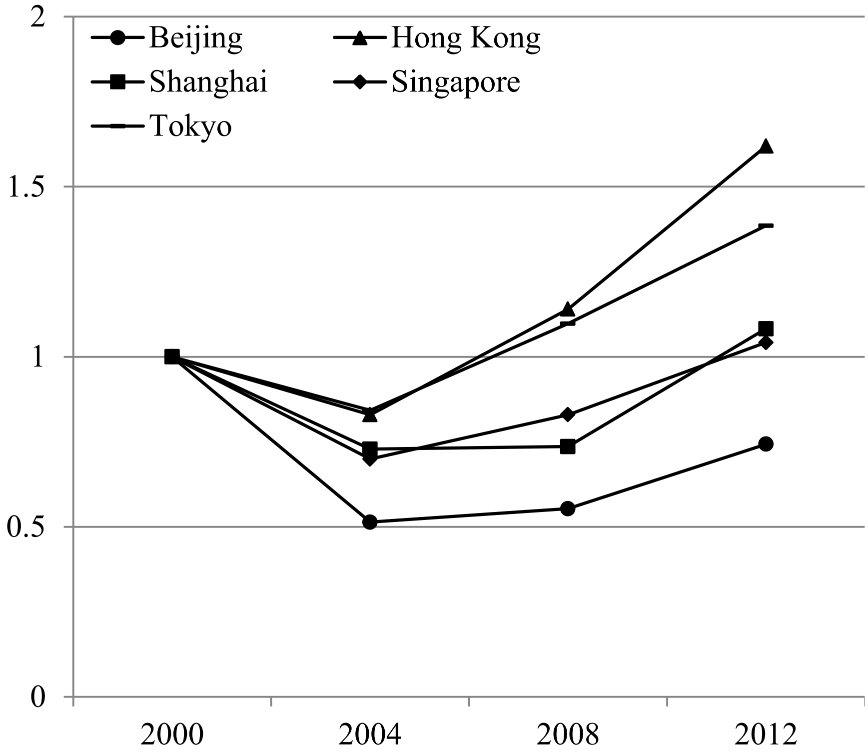
In contrast, the experience is very uneven among cities in the smaller Alpha class (Fig. 2 (C)). Some are establishing a stronger presence in the network of cities, while others are losing their influence. The analysis shows the increased importance of Seoul, an outcome undoubtedly linked to the strength of the Korean economy, along with the very substantial investments by Korean firms in East Asian countries, particularly in China (Debaere et al., 2010). The model's predictions for Taipei have become more prominent in this group. Here too, Taiwanese investments in China have been substantial (Fung el al., 2004). Furthermore, air passenger movements have been facilitated by some regulatory changes in Taiwan-China flights (Chang et al., 2011). In the case of Kuala Lumpur, Bangkok and Jakarta, however, the model's estimates of international traffic may be underestimated as the database used does not accurately count LCC operations. These three major cities in ASEAN are main home bases of important LCCs.

Among the cities in the Beta and Gamma classes seen in Fig. 2 (D), the model's estimates for Guangzhou, Hanoi and Ho Chi Minh City appear much more important in 2012 than in 2000. For Guangzhou, the change may be due to its new international airport which opened in 2004. The big gains for Hanoi and Ho Chi Minh City probably reflect Vietnam's recent boom in foreign direct investment (Barlkie, 2015). As for Shenzhen and Tianjin, their data on international air traffic was scarcely reported in 2000, so the standardization year used here may bias the results, influencing the positions of these two cities. For Shenzhen, proximity to Hong Kong may also limit its air traffic associated with business connections. Osaka, which was classified in a higher ranked category of cities than Seoul or Bangkok in the 1980's, is now in a lower tier; that is consistent with some earlier research showing loss of traffic to Tokyo (O'Connor and Fuellhart, 2010).

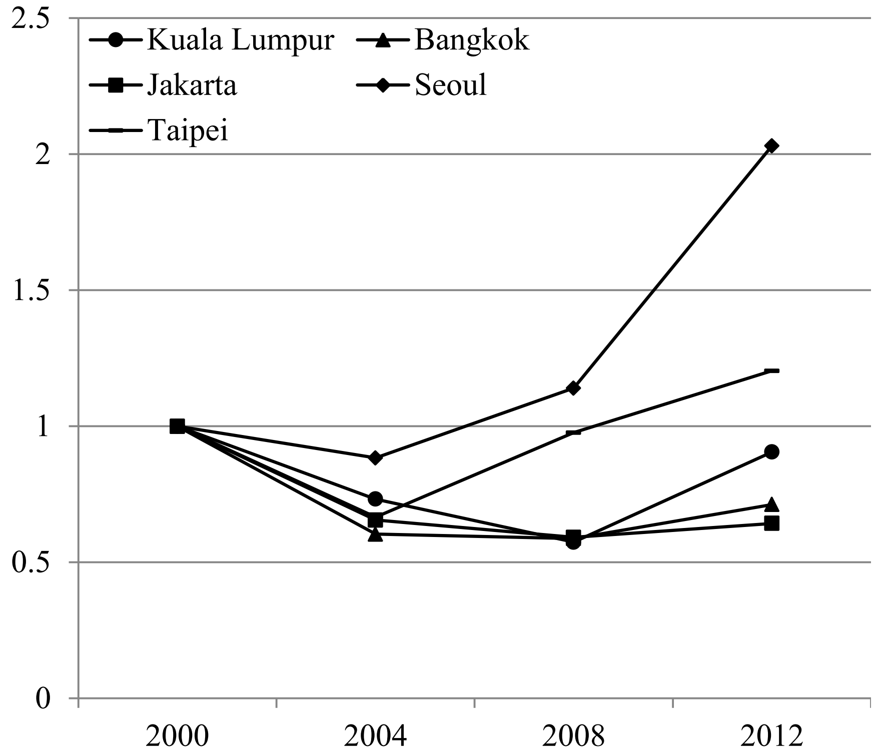
The previous studies by Matsumoto (2004, 2007) demonstrated that Tokyo, Hong Kong and Singapore were the three cores of international aviation in this region in 2000, and found that the air traffic role of Seoul and Hong Kong was growing at an extraordinary rate up to 2000. The results presented here, which have had the narrower focus just on East Asia, show that second ranked global cities, such as Seoul, Guangzhou, Ho Chi Minh City and Hanoi, have had the strongest gains after 2000. It seems the complex patterns of intra-regional connectivity in business and trade across this region since 2000 have drawn more cities into its air transport network.



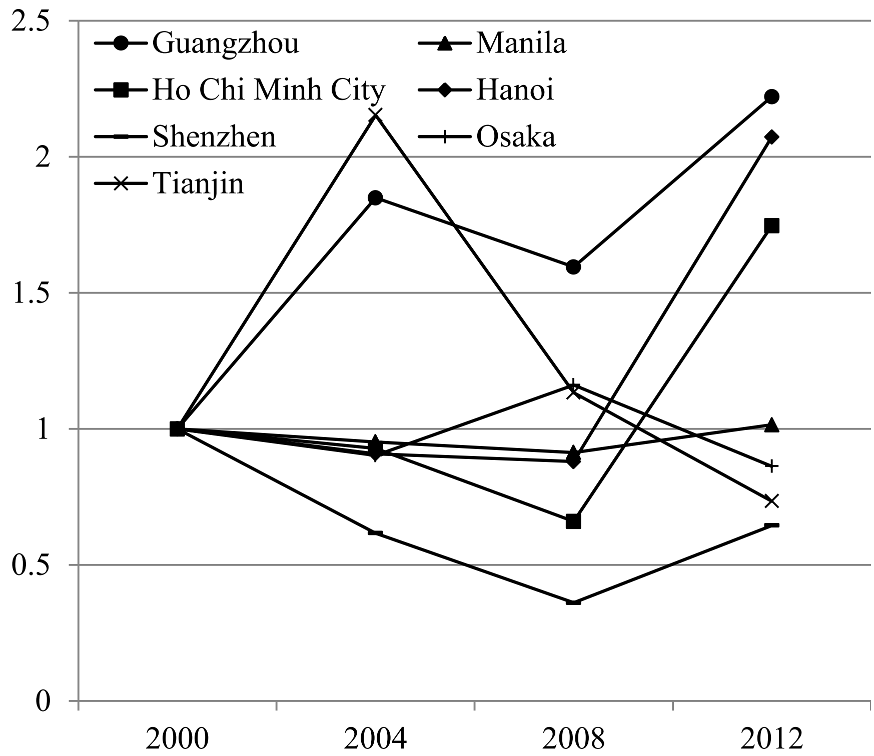
(A) The four basic variables.



(B) Alpha plus cities.



(C) Alpha and Alpha minus cities.



(D) Beta and Gamma cities.

Fig. 2. Parameter size relative to that in 2000.

5. Discussion and conclusion

The work presented here captures the dynamic change of the air transport city hierarchy within East Asia, where intense economic development has changed the relative rank of a number of cities, providing a stronger role for a number of previously second ranked cities. This research has shown that incorporating a measure of business connections into an established model, based upon general economic variables such as GDP and population, provides sharper predictions of city rank, and it also has been a stronger explanatory factor in the later years of the analysis.

These results refine our understanding of the way the economic development of the region actually shapes the air transport hierarchy, working as it does via the connections between important business service firms. Given that the nations of the region are likely to continue to intensify their commercial connections via trade and investment flows, the air passenger market and the roles of airports within a wide array of cities will play a more prominent role in the region's future. Passengers from, to and within this region 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). The implications for the planning and development of airports with the region are very significant.

It is important to recognize that these results have a narrow foundation, relying on a simple distance measure and on business connections. 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 South East Asia, and although much LCC activity is focused upon domestic markets, these carriers are extending links across South East Asia and increasingly into North Asia. As they grow, they will influence the role of their home based cities, notably Kuala Lumpur and Jakarta.

Incorporating these services will also widen the scope of the analysis beyond business service connections, as LCC airfares are likely to be very important for tourism, as well as visiting friends and relatives (VFR) travel, which includes the large movement of migrant workers such as construction workers from South Asia or housekeepers from the Philippines, and the intense networks of overseas Chinese throughout East Asia. The combined effects of these additional sources of demand will be influential on each city's role in international air passenger flows and could continue to re-shape the hierarchy of cities beyond the patterns detected in the current research.

A wider geographic scope could also be justified. That could bring India, Central Asia and Far Eastern Russia into the regional definition. In the case of India, the sheer scale of its market will have implications for increased engagement with the countries in East Asia, which will have implications for the results of research. In the same way, some geo-political decisions made by China to stimulate the old Silk Road connections will bring Central Asia into the region's air networks, which may have implications for some cities in Western China that acts as gateways to that region.

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). Even in South East Asia, where domestic markets (apart from Indonesia) are not large (when compared with Japan and China, for example), domestic seat capacity grew faster than that of international seats from 1998 to 2013 (Bowen, 2016). For the ideas in the current research, the scale of the domestic market served from a city could be considered as an extension of the importance of its business service linkages, as domestic services could indicate the reach of a city into its national market. Hence, in further work on the way business linkages shape the hierarchy of cities, some attention to the domestic linkages could be an important area to investigate.

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