Shanghai's role in the Asian cyber city network

using Google hyperlinks to measure Shanghai's development in the Information Age

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Abstract— **With the development of Information and Communication Technology (ICT), the rapid growths of Asian cities attract global attention on urban connectivity in the world network. Taking Shanghai as an example, this essay seeks to unpack the question of its changing position in Asian ICT network and ICT's contributes to sustainable urban development. The earlier ICT-based urban research and analysis tend to trace out "cyber" geography via physical infrastructure and material connection. Google search engine allows real-time data collection of intercity information flow, which is represented by hyperlink results in this essay. This study finds out that Shanghai is the leading cyber city in Asia compared with 2003, but it still needs to take advantage of ICT for sustainable development.**

Index Terms — **cyber cities, Shanghai, hyperlinks, ICT**

I. INTRODUCTION

The dramatic development of ICT makes the border and distance no longer an important factor in the global economic activities. Hyperbolic states that distance—and with it, place, city, and geography—is, or soon will be, "dead" (e.g., O'BRIEN, 1992; Negroponte, 1995; Kara, 1996) [1]. In spite of the demise of geography, new communication technology might destroy some geographies but in turn they will create other new geographies [2]. In fact, ICT has created a new space, namely, the cyber space. From one perspective, cyber space is a horizontal "network" of flows or an informational cloud above (or apart from) material reality, from another perspective, cyber space is inextricably linked to material reality [3]. The cyber city network, in which the information flows greatly shape the urban economy and globalization, is distinctive from the traditional city network.

Currently, the most interesting and remarkable efforts on world city network are from Taylor and Globalization and World Cities (GaWC). Taylor considers world cities as global services centers within an interlocking network of financial and business service firms, which are linked together by the communications of information, ideas, knowledge and instruction [2][4]. In his book *World city network: a global urban analysis*, Taylor [5] creates a model of advanced service office network, especially in the multinational firms, to characterize the powers, connectivity and pattern in the global network. However, comparing his model with the physical infrastructure network measured by airline passenger flows, Taylor [6] concludes that the world city network is consisted of various layers of space flows, which needs a cross-layer model and provides multiple roles that cities can play as nodes in the world city network.

A basic problem in the studies of world city network is the not readily obtainable data on relations between cities [2]. These studies use different criteria, in which Asia's major cities often appear in varying positions in the world city network. Knox [7] uses a three-level international categorization with a variety of criteria to measure globalness, in which Tokyo is in the First Tier, Singapore in the Second, and Seoul, Osaka, Taipei, Hong Kong, Manila, Bangkok and Mumbai in the Third. From the perspective of telecommunications, Short and Kim [8] measure the global air network (number of airline passengers, volume of air freight, and number of connecting air routes), to assess the "connectedness" of cities, in which Tokyo is the leading Asian global city, followed by Singapore and Hong Kong [8]. Recently, in The World According to GaWC 2010, Hong Kong, Singapore, Tokyo, Shanghai and Dubai belong to the Alpha+ world cities and Beijing, Mumbai, Kuala, Seoul and Jakarta are labeled as Alpha world cities [9]. These researches point out the need of considering other data for city ranking, including telematics, or the electronic production and integration of information economies [10].

Even though it makes some sense to examine the urban rank, it is argued that the discussion of urban hierarchy or urban rank might not be helpful when researching the network in the information age. The quickening and deepening connections, that is, flows between places, held to be characteristic of the contemporary globalizing world, called for new ways of apprehending the relative importance of cities in an "Information Age" [11]. But the challenge of operationalizing this prioritization of networks—flows and relationally over place—entities with attributes—was rarely addressed [12]. Castells [11] states that the further challenge is how to acknowledge that among the connections between cities are flows that are intangible and not simply embodied in people (in the case of airline network analysis) or places (in the case of studies that focus specifically on the physical, enabling infrastructure of electronic communications).

In previous studies, there is an absence of empirical elaboration of the information flows. Surprisingly, it is the age that information is everywhere, but when it comes to information relevant to world cities scholars, finding and

utilizing "good" data are relatively new developments. Boulton et al. [3] point out that newspapers and the World Wide Web are the two methods to measure the world urban network. In another empirical study of the cyber cities in Asia, Jack & Stanley [1] used Google search engine as a tool to measure the globalization of the cyber cities in Asia by examining the hyperlinks or URL reference to websites of Asian cities. However, there is a lack of quantitative research of using web search engine to measure urban network, especially the network evolution and the urban rank changes through time.

With the great development, Asian cities have attracted the interest of a large number of scholars from various disciplines. Currently, Shanghai itself has become increasingly competitive as it attracts foreign investment, and international activities, reaching a "global" city status. As the commercial and financial center in mainland China, Shanghai ranks fifth in the 2011 edition of the Global Financial Centers Index [13] and seventh as the alpha+ global city in the World According to GaWC 2010 [10]. Interesting is that the position of Shanghai is always changing in the global city network.

In summary, this study is proposed to unpack the question of Shanghai's position in relation to ICT network and ICT's impact on its development, meaning that this study will seek to understand the "cyber space" analysis of the global urban network by an empirical demonstration, exploring the value of Google search engine data as a means of understanding cities constituted by flows of digital information. Section II introduces the methods for data collection and analysis. In section III, compared with Jack & Stanley's study in 2003, it will discuss the characteristics of Asian cyber network and the changing role of Shanghai in the Asian cyber city network. Section IV will try to explore the reasons for such changes and possible connection between ICT network and sustainable development. The section V is the conclusion part, which will identify the contributions, limitations and the possible future development of this study.

II. METHODOLOGY

A. Study area

In the context of Asian, the selection of the cities is based on The World According to GaWC 2010 and Jack & Stanley's study. The 39 Asian cities for rank analysis are Hong Kong, Macao, Beijing, Shanghai, Guangzhou, Shenzhen, Tianjin, Taipei, Tokyo, Osaka, Kyoto, Hiroshima, Nagoya, Seoul, Singapore, Bangkok, Kuala Lumpur, Jakarta, Manila, Ho Chi Minh City, Hanoi, Mumbai, Bangalore, Kolkata, Hyderabad, Delhi, Chennai, Karachi, Lahore, Kabul, Dubai, Abu Dhabi, Jeddah, Riyadh, Manama, Tel Aviv, Doha, Kuwait City, and Amman. And then the 17 Asian cities for network connectivity analysis are Hong Kong, Beijing, Shanghai, Guangzhou, Taipei, Tokyo, Seoul, Singapore, Bangkok, Kuala Lumpur, Jakarta, Manila, Ho Chi Minh City, Mumbai, Bangalore, Dubai, Tel Aviv.

B. Data collection

According to Jack & Stanley [1], the hyperlink on the Internet can be used as an indicator to represent the information production and consumption. When entering a word or words into Google search engine, it will then provide us with the number of times that the word or those words appears in the database, and the URL and a brief description of the relating website. In this study, all the names of cities are searched in English in the Google Search engine. Three kinds of data are collected every day from 19th December to 25th December in 2013.

Number of hyperlinks per city shows the ranking of 39 cities in the Asian cyber space network. A city with a higher value of total hyperlinks will have a more important position in the cyber space network and larger potential to exchange information through the network. The result comes out as the same when entering "Shanghai China", "Shanghai, China", or "Shanghai+China". So, to obtain these data, we put in "City, Country" in the Google search engine, like "Shanghai, China".

Hyperlink per capita is calculated by the formulation "total hyperlink /metropolitan population". It indicates the degree of electronic information availability about that city for its residents. Therefore, the higher value means that there are more websites and information available for its residents.

Linkage between pairs of cities, here in this study, is measured to reflect the inter-city connectivity of 17 cities. A higher value of linkage between pairs of cities means stronger intercity connectivity. To obtain these data, we put in "Shanghai+Hong Kong" and record the number of URL.

C. Data analysis

Pareto distribution is a widely-used method to estimate the relation between urban size and urban rank to reflect the network structure. In this essay, the urban size is represented by the number of hyperlinks. Rosen and Resnick has used the following formula to examine the Paretoness for many countries based on the t-test in a reverse regression [14].

$$\log(R_i) \approx \alpha * \log^2(S_i) + \beta * \log(S_i) + \gamma \quad (1)$$

Where Ri = the rank of the city (number of cities with size S or greater); Si = the size (the hyperlinks) of a city. Equally, if $\alpha=0$, then there is a linear relation between the rank and the size.

Recently, Liu et al. [15] introduces Eq.2 to normalize the connectivity when using hyperlinks to measure the co-occurrence between two provinces.

$$N_{ij} = C_{ij} / (C_{ii} * C_{jj})^{1/2} \quad (2)$$

Where Cij denotes the hyperlink number of co-occurrences of city i and city j, Cii (Cjj) denotes the hyperlink number when only the name of city i (city j) is searched in the Google search engine.

Taylor [6] uses a standard least square regression analysis (Eq.4) to test the relation between airline passengers and network connectivity. Thus this model will also will used here to test the relationship between the connectivity and the economic growth.

$$N_i = \sum N_{ij}, \ j=1,2,3,\cdots, 16 \quad (3)$$

$$G = a*N_i + b + c \quad (4)$$

Where Ni denotes the sum of connectivity between city i and other cities, G denotes the GDP per capita of city i, b is the intercept of the G axis.

Finally, Jack & Stanley [1] have offered the research data of 2003, including Leading Asian cyber cities, Cyber links between largest Asia cities and Cyber links between largest Asia cities and other non-Asia cities. A comparison study between 2003 and 2013 illustrates the changes and evolution of the cyber space in Asia and between the major Asia cities and non-Asia cities.

III. Analysis

A. Cyber cities in Asia

The most obvious feature in Asia is the explosive growth of cyber city network. In terms of the total number of hyperlinks, the average daily hyperlink number of Hong Kong is 6970 times larger than that number in 2003, Singapore is 4156 times larger, Shanghai is 4138 times larger and Kuala is 13835 times larger (Table 1).

Secondly, a much stronger hierarchical structure and an unequal size distribution is a tendency for Asian cyber city network. Figure 1 shows that the linear relation between urban rank and the size of hyperlink is not so obvious. However, the majority of the value of log(H) is between 5.0 to 6.4, with only 2 the highest and 3 lowest. The estimated regression model here is as follow:

$$\log(R) \approx -0.348 * \log^2(H) + 3.286 * \log(H) - 6.142$$

$$\log(R) \approx -0.675 * \log(H) + 5.044$$

The strong hierarchical urban structure could be demonstrated by the total hyperlink of Asian cities as Well (see Fig. 2): Hong Kong (7270000000), Singapore (6218000000) and Delhi (2747000000). There is a huge gap between the second and the third Delhi (Hong Kong 2.64 times larger than Delhi and Singapore 2.26 times larger). Hence, the cyber cities in Asia are distributed quite unequally in such a cyber city network with just several dominant cyber cities (Hong Kong, Singapore) in the top.

Another tendency is the more accessible information use (see Table 1). For the hyperlink per capita, in 2003, only Singapore (1.60) and Macao (1.30) got the value above 1.00, while Hong Kong is only 0.67, Kuala 0.44 and Shanghai just 0.10. However, in 2013, all the selected 39 Asian cities get the value above 1.00. More specifically, Macao gets the highest value 2560, 1968 times larger than the number in 2003. Singapore follows with the value of 1206, 753 times larger than that in 2003 and Hong Kong is the third one within the value of 1023, 1526 times larger than that in 2003. Therefore, nowadays, individuals in Asia are much more accessible with sufficient

Table 1 Leading cyber cities of Asia, 2013 (number of hyperlinks in 1000)

rank	city	hyperlink (1000)	population (1000)	hyperlink per capita	hyperlink/min
1	Hong Kong	7270000	7106.000	1023.08	318.02
2	Singapore	6218000	5155.000	1206.21	272.00
3	Delhi	2747000	22242.000	123.51	120.17
4	Kuala Lumpur	1950000	6094.000	319.99	85.30
5	Beijing	1922000	17311.000	111.03	84.08
6	Kolkata	1716000	14374.000	119.38	75.07
7	Mumbai	1517000	16910.000	89.71	66.36
8	Macao	1516000	592.000	2560.81	66.32
9	Tokyo	1469000	37126.000	39.57	64.26
10	Shanghai	1139000	20860.000	54.60	49.83
11	Bangalore	1006000	8670.000	116.03	44.01
12	Tel Aviv	823700	3473.000	237.17	36.03
13	Kuwait City	811000	2695.316	300.89	35.48
14	Chennai	790000	8865.000	89.11	34.56
15	Abu Dhabi	786000	921.000	853.42	34.38
16	Seoul	760900	22547.000	33.75	33.29
17	Bangkok	649700	7151.000	90.85	28.42
18	Manila	646300	20767.000	31.12	28.27
19	Dubai	640300	2106.177	304.01	28.01
20	Hyderabad	601010	7903.000	76.05	26.29
21	Kyoto	501200	1473.746	340.09	21.92
22	Jakarta	445000	26063.000	17.07	19.47
23	Riyadh	438800	5037.000	87.12	19.20
24	Kabul	409000	3319.794	123.20	17.89
25	Ho Chi Minh City	287400	8314.000	34.57	12.57
26	Nagoya	278000	10027.000	27.73	12.16
27	Karachi	276600	20711.000	13.36	12.10
28	Guangzhou	259100	16827.000	15.40	11.33
29	Hiroshima	251700	1173.980	214.40	11.01
30	Lahore	239500	7743.000	30.93	10.48
31	Doha	204600	1312.947	155.83	8.95
32	Taipei	189800	8338.000	22.76	8.30
33	Shenzhen	180400	11885.000	15.18	7.89
34	Jeddah	148600	3456.259	42.99	6.50
35	Osaka	138300	17011.000	8.13	6.05
36	Manama	126800	329.510	384.81	5.55
37	Hanoi	117200	6500.000	18.03	5.13
38	Tianjin	64360	8922.000	7.21	2.82

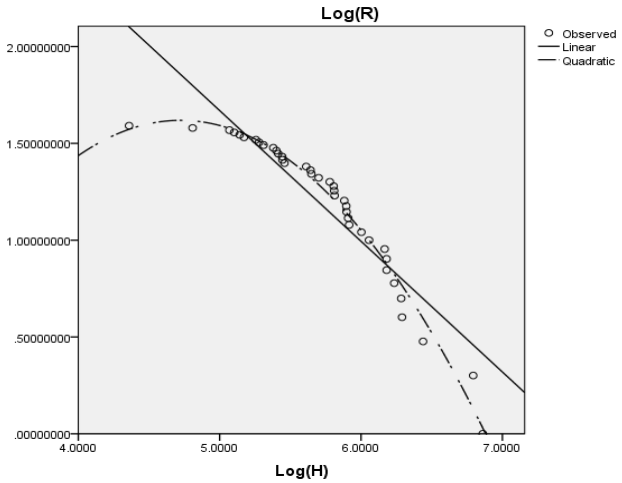

Figure 1 Rosen and Resnick's Pareto distribution of Total hyperlink

Figure 2 Largest cyber cities in Asia (total hyperlinks)

information they need for the urban life, which indicates and provides more opportunity for knowledge production.

B. Shanghai's rank in the Asia cyber city network

In the terms of the total hyperlink about the city itself, Shanghai itself only ranked 10 in 2013(see Table 1). Compared with its ranking of 8 in 2003, even though Shanghai has achieved significant breakthroughs in the ICT development, its growth rate is much slower than other Asia cities, for example, Delhi and Kolkata in India, Kuala in Malaysia. Hong Kong, a Special Administrative Region (SAR) in China, lives up to its reputation as the ICT hub in Asia in 2013. In a manner of speaking, the free Internet access contributes to Hong Kong's first place in Asia. Thus, to some extent, China's Internet access supervision policy adds Shanghai's falling position in Asia since not all information about Shanghai is freely accessible to the outside world. Besides, the language is also a factor, since Hong Kong uses English more widely than Shanghai, whose official language is Chinese.

C. Connectivity to the Asia cyber city network

In 2013, the most connected cyber cities in Asia are concentrated in the Eastern and Southeastern Asia. Instead, the cyber cities in the Western Asia and Southern Asia are relatively weakly connected with the rest Asian cyber cities. The strongest cyber linkage is between Hong Kong and Singapore (4373000) and the weakest linkage is between Taipei and Bangalore (49290). The linkage between Hong Kong and Singapore is 89 times larger than the linkage between Taipei and Bangalore.

In the China's cyber city network, only 5 cities are included, which are Beijing, Shanghai, Guangzhou, Hong Kong and Taipei. The data strongly suggests that Hong Kong and Shanghai are the leading cyber cities in China in 2013 (see Fig. 3). Hong Kong shows up as a leading cyber city and ICT hub in Asia. On the basis of the cyber links, Hong Kong's role of the global financial center is notably more apparent in linkages with other key financial cities: Singapore, Jakarta, Shanghai, Guangzhou, Tokyo, Dubai and Mumbai.

In terms of the cyber links of Shanghai, Shanghai is playing a more and more essential role in the Asian cyber city network. In Jack & Stanley's study (2004), they found a surprising conclusion that Shanghai, China's largest city in population and the country's economic powerhouse, lags behind in second place as a cyber city in China, ranking overall in Asia with 0.16 hyperlinks per capita. Yet, our findings for Shanghai's position are quite different. In 2003, Shanghai was ranked 6 in the cyber links to the rest Asian cyber cities, while in 2013 Shanghai achieves an increasing place, ranking 4. Besides, Shanghai is most strongly connected with Hong Kong and Jakarta, with a value of 2783000 and 2905000. On the one hand, the most weakly linkage is to Bangalore, only 326000 linkages. On the other hand, the well-connected cyber cities linked to Shanghai are Jakarta, Hong Kong, Singapore, Mumbai, Tokyo and Beijing, which are all emerging or existed global financial center in their countries. As the financial center in China, Shanghai's rising position in the Asia cyber city network is

Table 2 Comparison of the hyperlink rank: Shanghai and Hong Kong

	Hong Kong		**Shanghai**	
	2003	*2013*	*2003*	*2013*
Hyperlink	4470	7270000	1330	1139000
Hyperlink rank	2	1	8	10
Total Cyber links in Asia	13167	32482900	5033	23252300
Cyber link rank	1	1	6	4

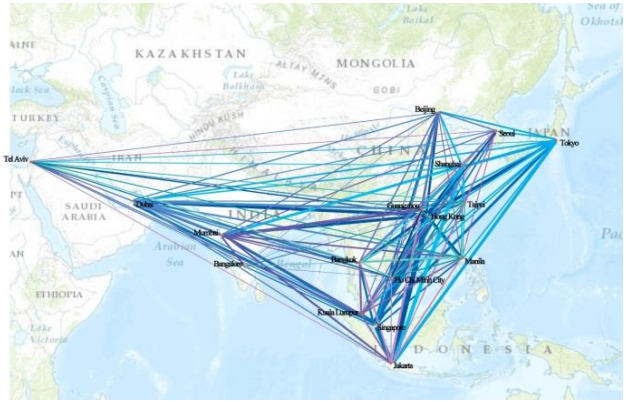

Figure 3 Asia cybercity connectivity network

Figure 4 Shanghai's connectivity in the Asia cybercity network

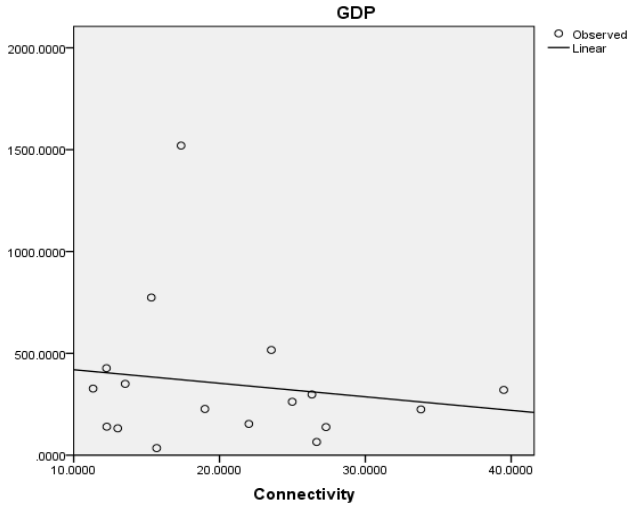

Figure 5 Regression analysis of city connectivity and GDP

probably a reflection of its frequent financial activities with other financial cities in Asia.

D. The relationship between Connectivity and Economic development

More interesting is that the regression analysis shows there is no clear relationship between GDP performance and city connectivity (see Fig. 5). This could be partly explained by the fact that in the capitalism, a city with higher connectivity will locate its industries around the world to achieve the highest profit. Also the lack of GDP data of ICT related industries is part of the reason for such result.

IV. Discussion

This study finds out some interesting facts and is intended to explore possible reasons for this connectivity changes. Hong Kong's leading position can be partly explained by the fact that even though Hong Kong is just a nodal city, its serving regions are far beyond its small territories, including most cities in Eastern Asia, Southeastern Asia and Southern Asia. Even more striking among Asian cyber city network considered here is the decreasingly lower position of Tokyo in the rankings in 2013. While Tokyo was ranked 3 in the cyber city network, as noted earlier in the Jack & Stanley's study (2004), in 2013 this premier ranking is not the case. In 2013, Tokyo only receives a ranking of 7 in our study. Surprisingly, the well-connected cyber cites to Tokyo are concentrated in China and Southeastern Asia. Jack & Stanley [1] state part of the explanation lies in the fact that Tokyo is not fully integrated into the English-speaking world, because the majority of the information are communicated and exchanged in Japanese in Japan. This could also be applied to Shanghai, since Chinese is the office language used in China. Therefore, our ranking of Shanghai may not reflect the actual situation. Although, Shanghai is increasing its rank in Asia, many efforts are still needed to improve its status: more free access to the Internet, English education, digital city construction and corporation with other city clusters.

Even though the regression analysis shows a negative relationship between connectivity and GDP, a lot of practices and literatures have indicated that the development of ICT could bring benefits to the urban development to some extent. ICT does indeed have the potential to enable new kinds of development practices to take place [16]. For example, ICT offers various new ways and possibilities for economic development, especially more advanced, high-value and healthy industries. Knowledge is a global common good to be widely shared [16]. Actually, Knowledge spillover is one of the effects generated by the ICT network, which is not discussed in this study. Cities with high connectivity in the network will have more chance to receive information, exchange knowledge and technologies, and communicate and cooperate with other firms and organizations. Consequently, cities will be more likely to obtain sustainable development. Further and continued studies need to be made on the connection between ICT network and ICT relating GDP growth, which will need more data of the development relating to knowledge industry and ICT industry. Such study could bring out different results from this study.

V. Conclusion

Whereas a great diversity of criteria is developed in the earlier efforts, this essay utilizes a very important element, hyperlink, to measure Shanghai's globalization and Asian cyber city network. In an innovative way, this study includes a factor of time and adopts the Google Search Engine to collect the data of information flows. From our analysis, conclusion could be drawn out that using data of these hyperlinks provides a new dimension to examine the cyber city rank in Asia and the network connectivity.

However, hyperlinks are but one more method that can be used to measure information flow in city network. By themselves hyperlinks may not be sufficient evidence to identify the Asian cyber city network and Shanghai's changing position. This study just compares Shanghai, Tokyo and Hong Kong's cyber links to the world. In this case, this study does not offer a detailed analysis of the cyber links between Asian cities and the non-global cities.

In this study, there are mainly two limitations. One is the insufficient data. Due to the time limitation, data are just collected for a period of a week period. In Jack & Stanley's

study, they collected the data in a month period. Hence, the analysis in this study is not perfectly accurate because of the quantity of the data. Another is the number of selected Asian cities. Jack & Stanley's study chooses all the Asian cities with a population more than 750000, while this study just selects 39 Asian cities according to the World According to GaWC 2010. Therefore, the analysis of the cyber cities and Shanghai's position may not in line with the reality.

There are a number of other intriguing questions that merit future study: If the research includes more Asia cities and a long period of data collection, how will the cyber city network in Asia change and how is Shanghai's position changing in this new network? What are the political, economic and cultural factors relating to the development of ICT in shaping Shanghai's position in such cyber city network? Given the fact that Asia becomes one of the economic power centers of the global economy, it is notable that Asian cities are definitely becoming more connected into the World system. So is Shanghai's rising status in the global urban system.

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