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Changing Connectivities of Chinese Cities in the World City Network, 2010–2016

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Abstract: Against the backdrop of the sizable economic growth of China in recent years, this paper uses the most recent data gathering of the Globalization and World Cities (GaWC) research network to update and supplement earlier research on the shifting global connectivity of Chinese cities. The update consists of an evaluation of the connectivity of Chinese cities in 2016, the supplement of an analysis of the changing position of Chinese cities in the world city network between 2010 and 2016. To this end, we build on a specification of the world city network as an 'interlocking network' in which producer services firms play the crucial role in city network formation. Information about the presence of leading producer services firms in cities in 2010 and 2016 is used as the input to a bipartite network projection algorithm in order to measure cities' network connectivity. The first set of results discusses the geographies of urban connectivity in the world city network in 2016. The second set of results discusses standardized measures of change to reveal the major dimensions of the transformations between 2010 and 2016. We find that, with the exception of Hong Kong, Macau and Kaohsiung of Taiwan, all Chinese cities record connectivity gains. This wholesale rise in connectivity is nonetheless geographically uneven, with above all Beijing, Chengdu/Chongqing and Changsha/Wuhan becoming more connected. We conclude that the wholesale rise of Chinese cities in the world city network and their changing trajectories in the post-crisis era are embedded in shifting external and internal political economies.

Keywords: world city network; producer services; changing connectivities; city; China

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1 Introduction

Derudder et al. (2013a) analysed the geographies of the global connectivity of major Chinese cities in 2010. To this end, they built on a specification of the world city network (WCN) as an 'interlocking network' in which producer services firms play the crucial role in city network formation (Taylor, 2001; Taylor et al., 2014; Taylor & Derudder, 2016). In drawing on a theoretically grounded measurement of WCN formation, they explicitly use Sassen's (1991) seminal writings on the 'global city' as the prime production site and market for financial, professional and creative services for corporate business. Sassen (1991) emphasises that all major economic agents have become increasingly dependent on producer services such as financial services, accountancy, advertising, law, and management consultancy offering customized knowledge, expertise and skills to

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their corporate clients. Some cities have thus acquired a particular component in their economic base that gives them a specific role in the current phase of the world economy: they are producer service centres that have a key enabling role in what have been increasingly integrated urban space-economies across the global economy. The service firms that are the heart of Sassen's (1991) writings have benefited immensely from the technological advances in telecommunications, allowing them to extend the geographical reach of their service provision.

Producer service firms have always clustered in cities, but a key element of their contemporary location strategies is that they are organising their work through multiple offices in large numbers of cities. This enables them to protect their brand integrity and offer a seamless service to their corporate clients operating in ever-larger markets (Pan et al., 2017a). Each firm has its own strategy in terms of the location and number of cities in its office network, as well as the size and functions of individual offices. To gauge the network formation in the office networks of services firms, research devised in the context of the Globalization and World Cities (GaWC) research network employs a model that treats the work done in these offices on projects that require multiple office inputs as 'interlocking' the cities in which they are located. Thus, these intercity relations through servicing practices consist of both electronic and embodied flows (for example, online exchange of information and sharing of knowledge, as well as face-to-face meetings involving business travel). It is these 'working flows', combined across numerous projects in many firms, which constitute the world city network as specified in GaWC research. The interlocking network model to study the world city network (WCN) thus allows calculating measures of connectivity of cities based on their integration in the office networks of producer services firms. Derudder et al. (2013a) used 2010 data for assessing the connectivity of Chinese cities in the global economy. In this paper, we update and supplement this analysis. The update consists of an evaluation of the connectivity of Chinese cities in 2016; the supplement of an analysis of the changing position of Chinese cities in the world city network between 2010 and 2016. In addition, we provide a comprehensive interpretation of results in light of China's unique political-economic context.

2 Methodology and Data

2.1 Study area

The 2010–2016 timeframe seems very pertinent to explore connectivity changes of Chinese cities. The economic implications of the United States subprime crisis and the ensuing European debt crisis have reinvigorated debates about a more general geographical shift in the global economy from 'West to East' (Frank and Denemark, 2014). Table 1 provides some macro-economic evidence of this shift through a range of overlapping regional-geographical lenses. In terms of economic output, international trade and outward foreign direct investment (ODI), this change has indeed been marked over this period, with above all the economic blocks of European Union (EU) and North American Free Trade Agreement (NAFTA) showing declining trends and that of Association of Southeast Asian Nations (ASEAN) and China upward trajectories in terms of economic output. However, the story is clearly more complex and multifaceted than this. For example, although NAFTA represents a smaller share in global economic output in 2015 than in 2010, its share in the world trade and ODI have continued to rise. Meanwhile, change in Asia was geographically varigated. The erstwhile 'Four Asian Tigers' (Hong Kong of China, Korea, Singapore and Taiwan of China) has been stagnating and even declining in terms of outward foreign direct investment (ODI). In contrast, most of China has been steadily growing on all possible economic fronts. China was not only hit relatively less hard by the economic upheaval following the financial crisis, it also recovered more quickly and has maintained a relatively high growth pace compared to rest of the world (Hu et al., 2014). From 2008 to 2015, the national GDP grew from 3.195×10^{13} to 6.891×10^{13} yuan (RMB), and this in spite of the rate of economic growth recently becoming somewhat less spectacular.

The relatively strong performance of China during this global downturn can to a large extent be traced back to a series of interrelated foreign and domestic policies announced and implemented by the Chinese government. In general, these policies were designed to alleviate the negative impact from the financial crisis and maintain a high economic growth rate (Chan, 2012; Zhou et al., 2011). This relative success in financial and economic terms has led China to become increasingly

Table 1 Major economic changes of selected economic blocks after the U.S. subprime crisis

Share of world GDP/trade/ODI	Economic block	Year		Change from 2010–2015 (%)
		2010 (%)	2015 (%)	
Share of world GDP	EU	28.29	26.33	–1.95
	NAFTA	30.00	29.51	–0.50
	ASEAN (+CN/JP/KR)	20.59	22.33	1.74
	BRICS	14.08	16.47	2.39
	HK/SIN/KR/TW	3.70	3.79	0.09
	CN	7.38	9.53	2.15
Share of world trade	EU	34.89	32.92	–1.97
	NAFTA	15.62	16.46	0.84
	ASEAN (+CN/JP/KR)	21.88	23.88	2.00
	BRICS	14.34	16.32	1.98
	HK/SIN/KR/TW	9.33	9.58	0.25
	CN	8.23	10.78	2.54
Share of ODI	EU	34.41	33.04	–1.36
	NAFTA	23.53	25.45	1.92
	ASEAN (+CN/JP/KR)	15.41	23.78	8.37
	BRICS	10.62	11.53	0.91
	HK/SIN/KR/TW	11.73	9.02	–2.71
	CN	4.94	8.65	3.71

Notes: EU (European Union), NAFTA (North American Free Trade Agreement), ASEAN (Association of Southeast Asian Nations), CN (China), BRICS (Brazil, Russia, India, China and South Africa), HK (Hong Kong of China), SIN (Singapore), KR (Korea), TW (Taiwan of China), JP (Japan). GDP is gross domestic product; ODI is outward foreign direct investment. Data source: United Nation Conference on Trade and Development (UNCTAD) (http://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx?sCS_Chosen Lang = en)

central to the global economy (Breslin, 2011), for example, China has now surpassed Japan to become the second biggest economy in 2010, and overtook the United States to become the biggest exporter in 2015. Two sets of policy packages seem particularly pertinent in the context of this paper. On the one hand, facing a drop in global demand and rising levels of protectionism, the Chinese central government actively encouraged a strategy of different kinds of ODI. More and more Chinese multinational enterprises began to seek their fortune abroad and avoid trade barriers via mergers and acquisitions. The 'exchange capital for technology and market' paradigm gradually replaced the erstwhile 'exchange market for technology' mode of development (Chen, 2011). In addition, multilateral cooperation strategies such as actively engaging with international organizations (e.g., the G20) and the newly proposed 'The Belt and Road Initiative' (B&R) epitomize a new range of ambitious plans to involve China in regional and international affairs. On the other hand, China sustained itself by increasingly exploiting its domestic market to offset the shrinking demand from abroad. The 4×10^{13} RMB fiscal stimulus package released by the central government was designed to boost the domestic consumer demand and expand the production capacity to (re)fuel the economic growth. The package covered a wide range of economic policies, including infrastructure network construction, housing projects, technology reforms etc. This domestic stimulus plan is believed to have played an important role in retaining stable and relatively fast growth after the crisis (Burdekin and Weidenmier, 2015). And it was implemented in conjunction with regional rebalancing policies as drafted in 'The Eleventh Five-Year Plan (2006–2010)' and 'The Twelfth Five-Year Plan (2011–2015)'. These policies embodied the 'East to West' strategy appear to have been successful in the sense some western and central parts of China have been economically (re)invigorated over the past few years (Li, 2012). Overall, the combination of these outward and domestic policies in post-crisis time not only have made China a more important economic power, but also addressed some of the imbalances in its regional development.

In any case, it seems clear that in the context of an uneven and lingering global economic crisis, a more multipolar world is emerging, with a rising role for Asia in general and a changing China in particular (Garrett, 2010; Chan, 2012). At the same time, erstwhile leading

blocs obviously remain crucial, and change is complex and multifaceted. Against this backdrop, a detailed geographical analysis of how these geo-economic shifts are reflected in the changing connectivity of major Chinese cities seems pertinent.

2.2 Cross-sectional model specification

World city network analysis implies moving beyond an assessment of the mere presence of producer services firms in cities (Ducruet et al., 2017): the idea is that the data are used in a way that allows measuring the inter-city relations created by producer services firms. Specifying the world city network (WCN) as an interlocking network, the inter-city connectivity r_{a-i} between two cities a and i in the office networks of all firms is defined as follows (Derudder et al., 2013a):

$$r_{a-i} = 100\% \times \frac{\sum_j r_{a-i,j}}{r_{\max}} = 100\% \times \frac{\sum_j v_{a,j} \times v_{i,j}}{r_{\max}} \quad (a \neq i) \tag{1}$$

in which $v_{a,j}$ and $v_{i,j}$ are the 'service values' of cities a and i; service values are essentially standardized measures of the 'importance' of a firm's presence in a city, often ranging from 0 to 5 (see below). The assumption behind this bipartite network projection is that the more important an office of firm j (as expressed by the service value), the more links there will be with other offices in firm j's network (i.e., a simple interaction model; for alternatives, see Neal, 2014). The global network connectivity GNC_a of a city a is then computed by aggregating all inter-city connectivities across the network:

$$GNC_a = 100\% \times \frac{\sum_i r_{a-i}}{GNC_{\max}} = 100\% \times \frac{\left(\sum_{i,j} v_{a,j} \times v_{i,j}\right)}{GNC_{\max}} (a \neq i) \tag{2}$$

As can be seen in equations (1) and (2), r and GNC measures are made independent from the number of firms/cities by expressing them as percentages of the largest computed connectivity $r_{\max}$ and $GNC_{\max}$. Thus in our analyses, connectivities range from 0 (no connectivity) to 100% for London , the most connected city.

2.3 Data

Precise specification guides our data gathering: we need to gather standardized service value data across a large number of cities and firms. The gist of the data collection and methodology has been explained in Derudder et al. (2013a), while the appraisal of how changes are measured has been discussed in Derudder and Taylor (2016). Readers are referred to these papers for operational details. In this section we discuss the basic elements of the data gathering in 2010 and 2016 to make this paper self-standing; in the next section we discuss how we calculate change.

2.3.1 Specification of firms

In the earliest GaWC data gatherings (Taylor, 2004), the selection of firms was based on a combination of two different criteria. First, a predefined notion of what constitutes a 'global locational strategy' was used. In practice, this implied only including firms with offices in at least 15 different cities, including one or more cities in Northern America, Western Europe, and Pacific Asia. Second, starting with rankings showing the top firms in different sectors, 100 firms were selected on the basis of the availability of information on their office network, in addition to a purely practical criterion: whether adequate information could be found on the firm's website. However, it subsequently became clear that this approach could be improved on a number of fronts. The starting point for the revised strategy is that we recognise that although most, if not all, major service firms have a lot of offices and/or an office in Northern America, Western Europe, and Pacific Asia, there is no conceptual need for this criterion (Robinson, 2005). Furthermore, using the same set of firms neglects that new businesses may enter the fray as their global presence/importance rises.

One of the most obvious examples here is the result of what Calkins (2013) has called the 'globalization of Chinese banks'. In his review, he points out that in line with the wider literature on the internationalization of producer service firms, the overarching logic underlying this globalization has been of, first, banks services expanding Chinese business abroad (especially those engaged in petroleum, construction and engineering industries, which require enormous credit lines to finance day-to-day operations), and, second, subsequently tapping into local markets. The first strategy has been dominant up till now. A clear-cut example is the expansion of the Industrial and Commercial Bank of China (ICBC). Calkins (2013) quotes Tian Zhiping, Chief Executive of ICBC Middle East, who points out that his

bank targets 'regions that have a significant number of Chinese businesses in operation already, which allows us to play the critical role of financial intermediary'. China's 'big four' banks (Bank of China, China Construction Bank, Industrial and Commercial Bank of China, Agricultural Bank of China) remain dependent on domestic financial operations for a majority of their annual revenue: current overseas operations by major Chinese banks account for less than 10% of their total assets. Nevertheless, banks such as ICBC have recently developed aggressive geographical expansion strategies, and have by now set up more than 200 subsidiaries and branch offices in 31 different countries and regions worldwide, according to the company's website (http://www.icbcltd.com/ICBCLtd/About%20Us/Global%20Websites/default.htm). Meanwhile, the Agricultural Bank of China has opened branch offices in New York, Hong Kong, Singapore and so on.

The key implication, of course, is that our data gathering should reflect the momentous growth of Chinese financial services firms (both in size and in geographical coverage), just as it should be able to deal with the demise of firms such as Arthur Andersen in the wake of the Enron fiasco. As a consequence, we have decided to simply focus on leading service firms in their respective sectors. This straightforward approach also has the advantage that it facilitates future replication of the data gathering. Thus the data gatherings in 2010 and 2016 feature 175 firms in five sectors: 75 financial services firms, 25 management consultancy firms, 25 advertising firms, 25 law firms, and 25 accountancy firms. Criteria for inclusion in 2016 were as follows (a similar strategy was used in 2010): for financial services, we included the top 75 most valuable banking brands were identified as ranked in Brand Finance's Banking 500 (published February 2016; http://brandfinance.com); for accountancy the revenue ranking by World Accounting Intelligence (published February 2016, http://www.worldaccountingintelligence.com); for advertising the revenue ranking of 'marketing organizations' by Advertising Age (published December 2014,http://www.adage.com); for law the revenue ranking by American Lawyer's Global 100 ranking (published September 2015, http://americanlawyer.com); and for management consultancy the Vault Management & Strategy Consulting Survey evaluating prestige, quality of life and overall best to work for (published 2016, http://www.vault. com). Substitute firms were identified for each sector (ranking just below the top 75 and 25) to cover for situations where a firm had disappeared (e.g. been taken over) over the course of the data collection.

2.3.2 Specification of cities

A few of the larger firms have branches in many hundreds, even thousands, of cities and towns. The data collection has been restricted to the more important cities for two reasons. The first is analytical: the more cities included, the sparser the final matrix will become with nearly none of the firm networks present in the smaller cities and towns. The second is theoretical: the interest is in the more important inter-city relations. Nevertheless, it is also important not to omit any possible significant node in the world city network so that a relatively large number of cities needs to be selected. Similar to our selection of firms, our criterion for inclusion in the most recent data gathering is based on a revision and an extension of the initial data gathering.

The initial ad hoc selection of 315 cities in Taylor (2004) was biased towards Northern America, Western Europe, and Pacific Asia (Robinson, 2005). To ensure that all world-regions are reasonably represented, we have devised a new and more inclusive roster of cities. In addition to the original 315 cities that featured in the 2000 data collection, in the 2010 and 2016 data gatherings we also included all cities with a population of more than 1.0×10^6 inhabitants; all capital cities of states with a population of more than one million, and every city with a headquarter office of one of our selected firms. This led to the selection of 525 cities in 2010 and 708 cities in 2016 that are used in recording information on the 175 global service networks.

2.3.3 Specification of service values

Our approach for measuring WCN formation is based on a measurement of the presence of major producer services firms in major cities: the service values in equations (1) and (2). As locational strategy is an integral part of producer services firms' public marketing and recruitment policies, it tends to be quite transparent. Typically, the websites of such firms provide an option to select 'locations' giving addresses of offices, often with a map of their distribution to emphasise their global presence. Advantage is taken of this transparency for information gathering. Our data collection strategy is therefore to find basic information on corporate web-

sites about the locations of major service firms.

In practice we 'scavenge' these corporate websites for all possible relevant information. For each firm, two types of information are gathered. First, information about the size of a firm's presence in a city is obtained. Second, the extra-locational functions of a firm's office in a city are recorded. Headquarter functions are the obvious example but other features like subsidiary headquarters and regional offices are recorded. Any information that describes these two features of a firm′s presence in a city is collected, after which it is standardized into data. A six-point scale is used for service values where two levels are automatically given: obviously 0 is scored where there is no presence of a firm in a city, and 5 is scored for the city that houses a firm's headquarters. Hence decision making on scoring focuses upon allocating the middle four scores (1, 2, 3, and 4) to describe the service value of a firm in a city. This means that for each firm three-boundary lines have to be specified: between 1 and 2, 2 and 3, and 3 and 4. The basic strategy of allocation is to begin with the assumption that all cities with a non-HQ presence of a firm score 2. This score represents the 'normal' or 'typical' service level of the given firm in a city, after which the score is altered if there is a specific reason. For instance, a city where contact with its office is referred elsewhere will be scored 1 for that firm. Generally, the boundary between 2 and 3 has been based upon size factors and that between 3 and 4 on extra-territorial factors. For instance, exceptionally large offices with many practitioners will lead to a city scoring 3 while the presence of regional headquarters will lead to a city scoring 4. In practice, size and extra-territorial information have been mixed where possible in deciding on the boundaries for each firm.

The end results are 525 cities × 175 firms (for 2010) and 708 cities × 175 firms (for 2016) matrices of that will be used as the input to the longitudinal analysis. There are 38 and 107 Chinese cities included in each set of city samples respectively. Given the changing number of cities in our data gathering, we will only focus on the cities that are present in both data gatherings. In addition, for reasons of statistical robustness, in this paper, we only consider those cities that have a GNC of at least 10% in either analysis—this produces a total of 344 cities worldwide, of which 29 Chinese cities, for further analysis.

2.4 Measuring the change of global network connectivity

Having different snapshots of the world city network in 2010 and 2016 allows analysing the trajectories of individual cities and regions (Orozco-Pereira and Derudder, 2010). The first and most straightforward way to explore changes in the world city network would be to explore shifting ranks between 2010 and 2016. However, assessing shifting ranks or levels of GNC has some severe limitations as a way of appreciating change. Drawing on previous longitudinal analyses (Derudder et al., 2010; Derudder & Taylor, 2016), we therefore develop a methodology that allows for a more nuanced assessment of change in the world city network. Most of the limitations of simply looking at changing levels of connectivity can be traced back to this constituting a closed number system. However much more connected the leading city becomes, it cannot show additional connectivity through its GNC measure of unity. In more general terms, there is a problem of possible underestimation of change at the higher ends of the scale. This problem consists of two components: 1) a measurement problem in that higher ranked cities have less leeway to increase their connectivity because they are nearer the limit of the measurement scale, i.e., a city with a global network connectivity of 95% can only increase its connectivity with 5%, while London simply can not and 2) a conceptual problem in that the markets of higher ranked cities are closer to saturation in that they have less leeway to acquire more/larger/more important offices, i.e., a city where all major service firms have a major office can hardly become more important in the office networks of these firms.

The solution consists of two consecutive standardizations that tackle both problems. First, the problem of the closed number system is tackled by generating standardized measures of connectivity change. To this end, we compute standardized global network connectivities for both 2010 and 2016 as *z*-scores. For both cross-sections, this produces an open number sequence pivoting on zero (average connectivity) with individual cities expressed as standard deviations from the average. A city's connectivity change can then be calculated by subtracting the 2010 value from the 2016 value, which is in turn standardized. This produces a measure of standardized global network connectivity change (SGNCC): an open number sequence pivoting on zero (average connectivity change)

with individual cities' change expressed as standard deviations from average change:

$$SGNCC_a = \frac{n \cdot \left[SGNC_{a(2016)} - SGNC_{a(2010)}\right] - \sum_i \left[SGNC_{i(2016)} - SGNC_{i(2010)}\right]}{\sqrt{n \cdot \sum_i \left\{\left[SGNC_{i(2016)} - SGNC_{i(2010)}\right] - \frac{1}{n}\sum_i \left[SGNC_{i(2016)} - SGNC_{i(2010)}\right]\right\}^2}} \quad 1 \le i \le n \tag{3}$$

where:

$$SGNC_a = \frac{n \cdot GNC_a - \sum_i GNC_i}{\sqrt{n \cdot \sum_i \left[GNC_i - \frac{1}{n}\sum_i \left(GNC_i\right)\right]^2}} \tag{4}$$

Second, there is the issue of possible market saturation in cities that were already well connected in 2010. Fig. 1 presents a scatter plot in which the *Y*-axis represents SGNCC for the period 2010–2016 for all cities that had a connectivity of at least 10% in either 2010 or 2016; the *X*-axis represents cities' GNC in 2010. While the figure provides an immediate and compelling picture of the most upwardly and downwardly mobile cities, it also shows that there is indeed a small but statistically significant negative correlation ($r = -0.215$, $P < 0.01$) between both indicators: the distribution of connectivity in the world city network has become 'flatter' as, on average, above all initially less-connected cities have become more strongly integrated in the office networks of producer services firms. The straightforward solution to this problem is to use the standardized residuals from

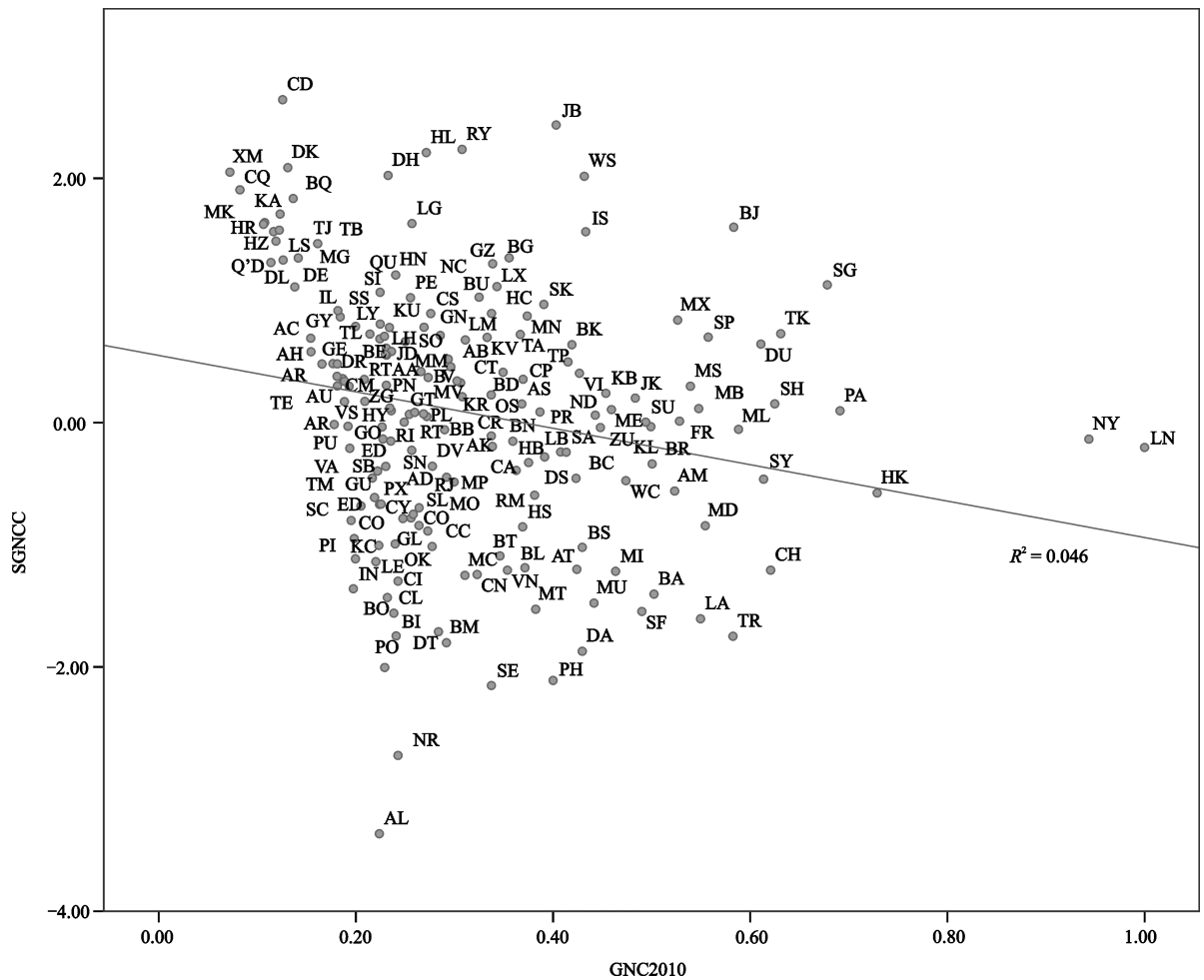

Fig. 1 Scatterplot of correlation between global network connectivity (GNC) for 2010 and standardized global connectivity change (SGNCC) for 2010–2016. Codes of cities are showed in Appendix Table

the regression line shown on the graph as our actual measures of SGNCC. This second transformation produces a new version of SGNCC with the same parametric characteristics: a standard normal distribution in that its average is 0, its standard deviation equals 1, while statistical testing using Kolmogorov-Smirov tests show that this distribution can indeed be considered to be normal. As a consequence, SGNCC can be interpreted as a *z*-score. For example, cities with an absolute value of ≥ 2 have witnessed exceptional connectivity change in 2010–2016, while cities with a value close to 0 have seen a connectivity change in line with the change in the distribution at large.

3 Results

3.1 Geography of global network connectivity in 2016

Throughout the results section, results are shown on a cartogram illustrating the most connected cities because this mode of presentation solves the problem of illustrating a very uneven distribution of cities across the world. Relative city concentration in some regions (e.g., in western Europe) coupled with relative sparseness of cities elsewhere (e.g., in central Asia) makes depiction of results on orthodox maps sometimes difficult to perceive and interpret. Hence the use of a cartogram, where each city is given its own equal space in approximately its correct relative position. Cities are indicated by intuitive two-letter codes, e.g., 'NY' for New York and 'JB' for Johannesburg (see Appendix Table). We have had to limit the number of cities to aid comprehension of the cartogram and so as not to lose sight of the leading cities across the world. We only show cities with at least 20% of the connectivity of the most connected city (London) in 2016; in the next section, we only show cities with at least 20% of the connectivity of the most connected city (London) in either year. In the tables, for Chinese cities, we use 5% as our threshold. These cut-off points are purely arbitrary. It has been chosen because it gives a reasonably large number of cities across world regions.

Fig. 2 thus shows a global archipelago of cities with a connectivity of at least 20% in 2016, with darker shades reflecting stronger connectivity. The figure shows that there is indeed a worldwide pattern of global service centres, albeit clearly an uneven one. At its simplest, the cartogram reproduces the old 'North-South' divide: higher connected cities tend to be in the 'North' and lower connected cities in the 'South', with the western Pacific Rim firmly bucking this trend. But the geography is, of course, much more complicated. Although the figure illustrates the three contemporary zones of the

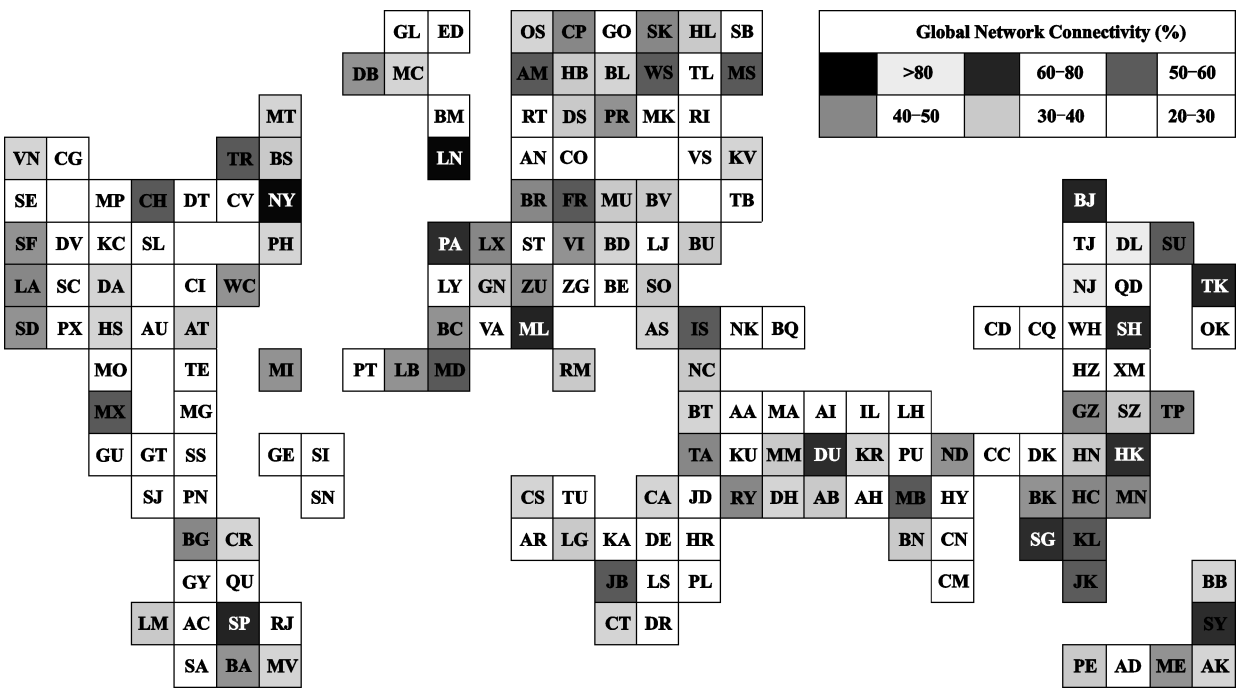

Fig. 2 Global network connectivity in 2016. Codes of cities are showed in Appendix Table

core of the world-economy: northern America, Western Europe and parts of Pacific Asia, this is not a homogeneous core, as the three zones have very different histories associated with their trajectories to core status.

The first core zone, Western Europe, has more world cities (36) than the other regions. Furthermore, there is a wide variety of levels of connectedness amongst the region's cities, ranging from the likes of London and Paris to the likes of Leeds and Rotterdam. In other words, in this region, there is a mixture of cities of varying importance all linking into the world city network. The second core zone, northern America (i.e. USA and Canada), has a smaller number of world cities than the former one (27). However, the range of levels of connectedness is very similar to Western Europe with numerous less important cities such as Kansas City and Cincinnati joining the world city network alongside well-connected cities such as New York and Chicago. But there are regional differences in that, in North America, the more connected cities tend to be in the east and west of the region, leaving the centre bereft of well-connected cities apart from the major exception of Chicago. The third core zone, Pacific Asia, has a similar number of cities (25), but it lacks a city with the level of connectivity of New York and London. One key finding is that more than half of these cities are Chinese cities. There are two major axes in geographical terms: there is a coastal corridor (Hong Kong-Shenzhen-Guangzhou-Xiamen-Hangzhou-Shanghai-Nanjing-Qingdao-Tianjin-Beijing-Dalian), but also a westward axis is emerging on the map of the world city network (Shanghai-Wuhan-Chongqing-Chengdu). This 'bow-and-arrow' like extension within China is a new feature of the geography of the WCN.

Beyond the core there are no regions with concentrations of highly connected cities. In Eastern Europe (the former Communist states), the most common pattern is for capital cities to take on the world city role: apart from St. Petersburg, the only cities (13) that feature are capital cities. Having lost its political and economic distinctiveness, this region has become an appendage to the western European core, albeit that unlike western Europe there is only one well connected city (Moscow) and much more concentration with generally one (capital) city per state. The same can be said for Latin America (23) with respect to northern America where again capital cities dominate. Only in the case of Sao Paulo, despite being neither former nor current Brazilian capital city, has become a highly connected world city in its own right. Together with Mexico City, this city stands out in Latin America. This pattern is also found in South Asia (13) and the large North African/West Asian region (17), where Mumbai and Dubai as non-capital cities have become highly connected world cities. Sub-Saharan Africa has only 10 cities but it does sport a clear regional leading city in terms of connectivity: Johannesburg.

Table 2 presents an overview of the 20 cities with the largest global network connectivity (GNC) in 2016. Our analysis shows that London and New York are by far the most connected cities. Beyond this clear-cut top two, the distribution suggests a scale-free network in that there are no major differences in connectivity. Singapore has entered the top 3, whereas in previous years Hong Kong occupied this spot. Together with Fig. 2, the most prominent geographical feature of this result is that, as suggested more than two decades ago by Sassen (1994), the WCN seems to cut across erstwhile North/South and/or East/West divides, with major connectivity for

Table 2 Global network connectivity (GNC) of the twenty most connected cities in the world city network (WCN) in 2016

Global ranking	City	GNC (%)
1	London	100.00
2	New York	95.65
3	Singapore	75.40
4	Hong Kong	74.89
5	Paris	70.39
6	Beijing	69.18
7	Tokyo	68.38
8	Dubai	67.70
9	Shanghai	66.96
10	Sydney	61.28
11	Sao Paulo	59.70
12	Milan	59.67
13	Chicago	58.12
14	Mexico City	57.48
15	Mumbai	57.28
16	Moscow	56.47
17	Frankfurt	55.89
18	Madrid	53.24
19	Warsaw	52.96
20	Johannesburg	52.85

cities as diverse as Shanghai, Sao Paolo, Sydney, Toronto, Mumbai, Warsaw and Johannesburg. There are three Chinese cities in the top 10: Beijing, Shanghai and Hong Kong.

Table 3 and Fig. 3 provide an overview of the 47 Chinese cities with GNC larger than 5% in 2016. Although Hong Kong, Beijing and Shanghai stand out in terms of connectivity, this is not simply a top-heavy pattern with 'other' cities playing minor roles at best. Indeed, there are patterns, including a clear-cut regionalised pattern in the GNC distribution of Chinese cities. With the exception of Tibet, each province has at least one city in the Table 3, most of them are provincial capitals. The widespread mushrooming of Chinese cities 'on the map' suggests that urban China as a whole, although unevenly so, is becoming integrated in the WCN. Another important geographical feature of our results is the 'megaregional' clustering of connectivity (Harrison and Hoyler, 2015). As can be seen in Fig. 3, there are three regional clusters of connectivity, i.e. the Pearl River Delta region (PRD, Hong Kong), the Yangtze River Delta region (YRD, Shanghai) and the Bohai Bay region (BB, Beijing). In addition, several somewhat sparser clusters have come into being (see Liu et al., 2016, 2017), including Chengdu-Chongqing, Wuhan-Changsha-Nanchang, and Fuzhou-Xiamen-Taipei-Kaohsiung on both sides of Taiwan Strait. Taken together, a diamond-shaped spatial backbone (Li, 2012) of cross-country world city agglomerations has formed in China. Chengdu and Chongqing in particular are strongly connected and thus appear to benefit from the national 'Strategy of Exploitation of the West', and is emerging as the forth economic pole following the YDR, PRD and BB megaregions. Similar to Chengdu and Chongqing, Wuhan as the underpinning point of 'Strategy of the Rise of Central China', is also taking full advantage of some significant preferential policies as well. Overall, the geographical structure of the

Table 3 Global network connectiveity (GNC_a) of Chinese cities in world city network (WCN) in 2016 ($GNC_a > 5\%$)

Global ranking	City	GNC_a (%)	Global ranking	City	GNC_a (%)
1	Hong Kong	74.89	25	Macau	13.24
2	Beijing	69.18	26	Taiyuan	12.87
3	Shanghai	66.96	27	Changchun	12.33
4	Taipei	45.64	28	Hefei	12.09
5	Guangzhou	43.27	29	Ningbo	11.30
6	Shenzhen	32.18	30	Zhengzhou	10.86
7	Chengdu	28.25	31	Nanning	10.80
8	Tianjin	27.02	32	Harbin	10.50
9	Nanjing	22.87	33	Ürümqi	10.03
10	Hangzhou	22.81	34	Nanchang	9.19
11	Qingdao	22.57	35	Hsinchu	9.04
12	Dalian	21.19	36	Guiyang	8.96
13	Chongqing	20.95	37	Zhuhai	8.67
14	Xiamen	20.14	38	Haikou	8.53
15	Taizhong	19.30	39	Shijiazhuang	8.05
16	Wuhan	18.84	40	Lanzhou	7.73
17	Suzhou	18.25	41	Yinchuan	7.45
18	Changsha	18.05	42	Tainan	7.40
19	Xi'an	17.50	43	Hohhot	7.21
20	Shenyang	17.32	44	Wuxi	6.94
21	Jinan	16.79	45	Taoyuan	6.36
22	Kaohsiung	15.10	46	Xining	5.98
23	Kunming	14.51	47	Weifang	5.17
24	Fuzhou	14.04			

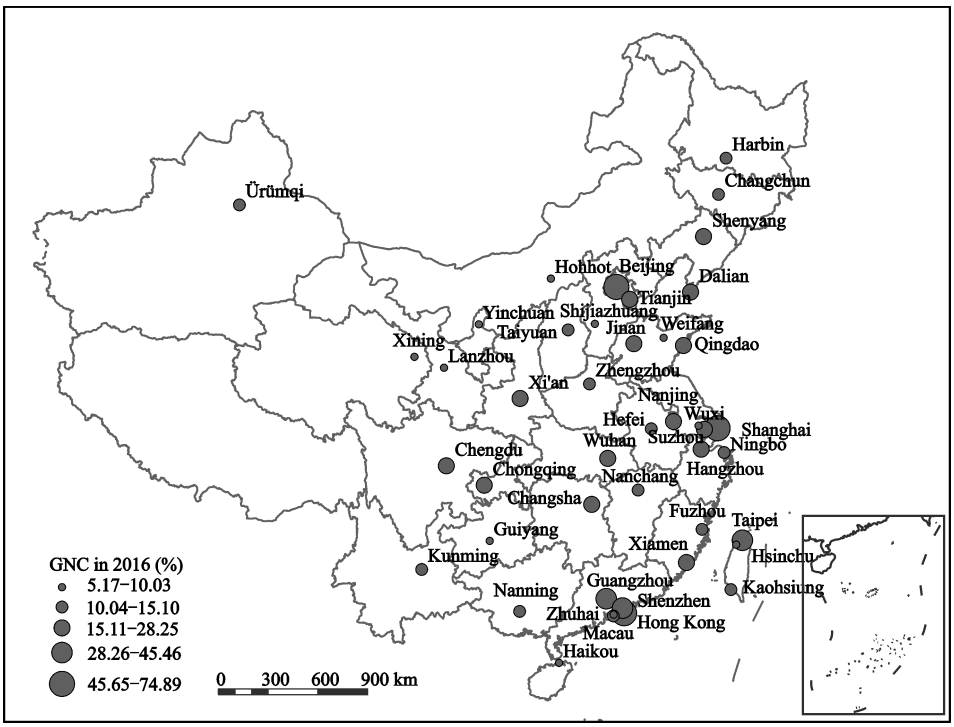

Fig. 3 Forty-seven Chinese cities with global network connectivity (GNC_a) > 5% in 2016

regionalised world city clusters in China is in accordance with the actual urban agglomeration development patterns as set out in national spatial plans. In 2010, The State Council of the People's Republic of China released 'The Strategy of Major Function Oriented Zones'. It strongly emphasizes the new vision of the central government to rebalance the uneven economic development (Fan et al., 2012), in line with these regional clusters (the development-optimized and development-prioritized zones), and our results parallel these development patterns (Fig. 4).

3.2 Change in world city network, 2010–2016

Figs. 5a and 5b picture positive and negative SGNCC in the period of 2010–2016. Pacific Asian cities in general and Chinese cities in particular show signs of rising levels of connectivity, while most north American cities show declining levels of connectivity. Europe exhibits a more mixed pattern, with UK cities declining and a city such as Luxemburg gaining connectivity. Cities in Sub-Saharan Africa and East Europe register medium gains in connectivity; a similar pattern can be found in Latin America and South Asia. In the Middle East, Doha and Riyadh have become much more connected, and now more closely follow Dubai and Abu Dhabi.

Along with these geographical patterns of change, there is also stability. In Table 4, which lists the 20 most connected cities in both 2010 and 2016, this stability shows from the fact that 18 cities feature in both lists, with the top six consisting of the same set of cities. New York and London, although being at the centre of the global financial crisis, continue to tower over other cities in terms of global network connectivity (Wójcik, 2013). Both cities appear to function as 'isolated islands' whose connectivity is not that much impacted by macroeconomic conditions in their respective countries; Bassens and van Meeteren (2015) have recently hypothesized both cities to be 'obligatory passage points' in a financialised global economy in which producer services firms play a key role. Meanwhile, Shanghai and particularly Beijing recorded further connectivity gains, and have significantly reduced the connectivity gap with Hong Kong.

Table 5 lists the standardized global network connectivity connectivity change of Chinese cities with a GNC_a>10% in 2010 and 2016. Fig. 6, in turn, maps the geographical distribution of these cities' standardized connectivity change. One of the major findings is that Beijing has witnessed a more rapid connectivity gain than Shanghai, and the former ranked above the latter in

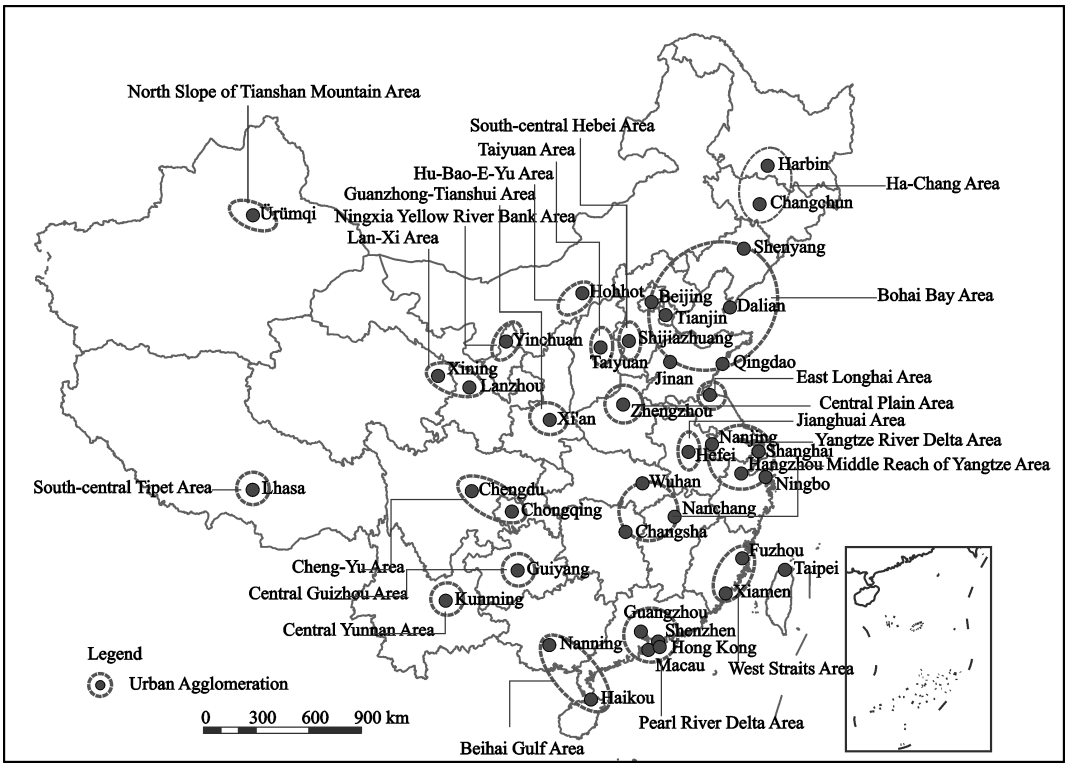

Fig. 4 Strategy of urbanization structure in China (from 'The Strategy of Major Function Oriented Zone') (The State Council of China, 2010, http://www.gov.cn/zwgk/2011-06/08/content_1879180.htm)

Table 4 The most connected 20 cities in 2010 and 2016

2010			2016		
Global ranking	City	GNC_a (%)	Global ranking	City	GNC_a (%)
1	London	100.00	1	London	100.00
2	New York	94.35	2	New York	95.65
3	Hong Kong	72.87	3	Singapore	75.40
4	Paris	69.11	4	Hong Kong	74.89
5	Singapore	67.82	5	Paris	70.39
6	Tokyo	63.10	6	Beijing	69.18
7	Shanghai	62.49	7	Tokyo	68.38
8	Chicago	62.07	8	Dubai	67.70
9	Sydney	61.36	9	Shanghai	66.96
10	Dubai	61.08	10	Sydney	61.28
11	Milan	58.81	11	Sao Paulo	59.70
12	Beijing	58.32	12	Milan	59.67
13	Toronto	58.25	13	Chicago	58.12
14	Sao Paulo	55.74	14	Mexico City	57.48
15	Madrid	55.44	15	Mumbai	57.28
16	Los Angeles	54.96	16	Moscow	56.47
17	Mumbai	54.78	17	Frankfurt	55.89
18	Moscow	53.93	18	Madrid	53.24
19	Frankfurt	52.83	19	Warsaw	52.96
20	Mexico City	52.64	20	Johannesburg	52.85

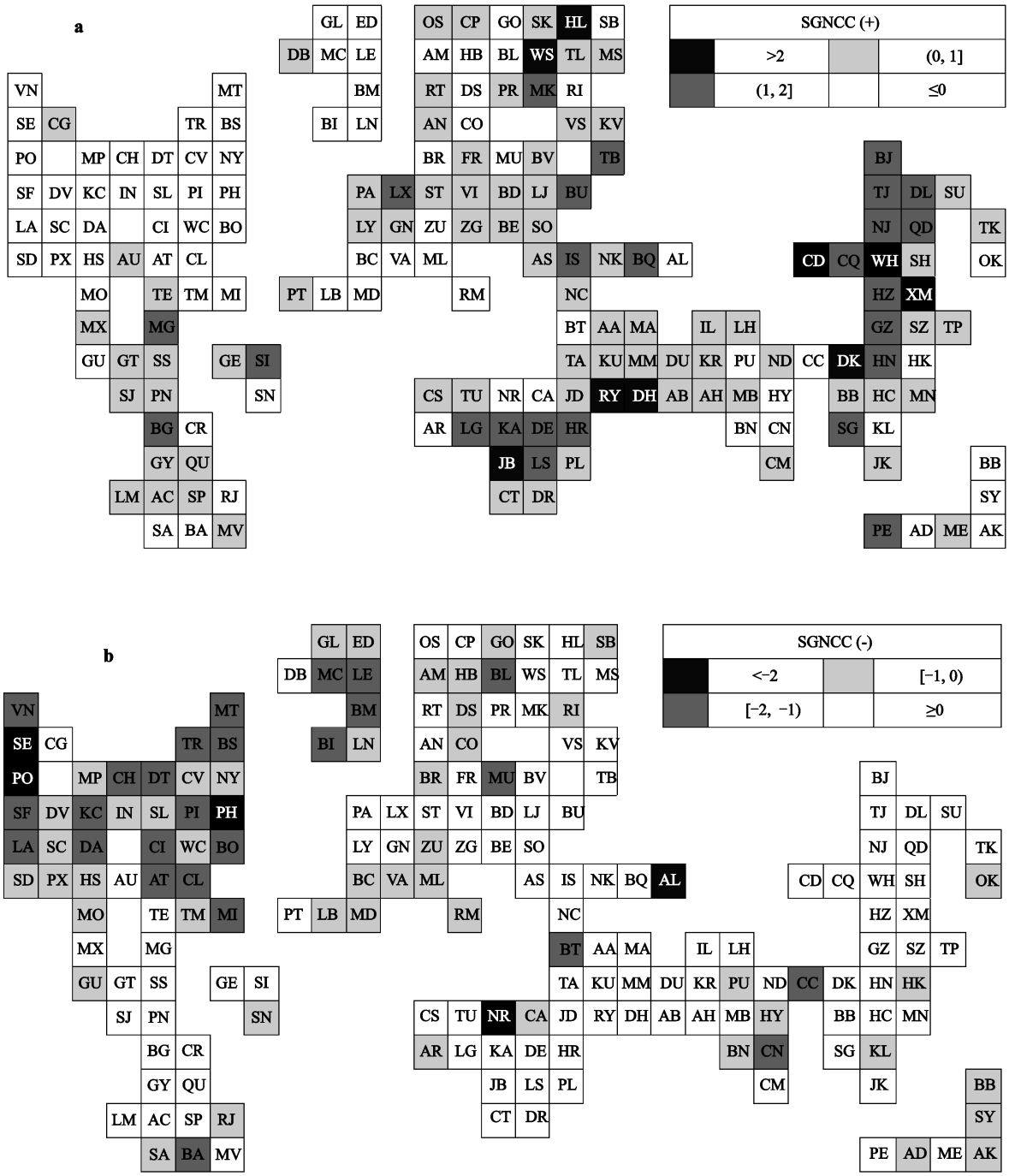

Fig. 5 Standardized global network connectivity change (SGNCC) (a. positive; b. negative) in the world city network, 2010–2016 (the codes of cities are showed in Appendix Table)

2016. A possible interpretation of this is that after joining in the WTO, the central government of China has slowly started shifting away from an inward FDI-dependent development mode by gradually introducing the 'Going Global Strategy'. In addition to focusing on domestic consumption, a series of policies have been implemented to shift the FDI from being mainly on the receiving end (China as 'world factory') into becoming a net investor. In the wake of the 2008 crisis, with this ambitious goal, China has further sped

Table 5 Standardized global network connectivity change (SGNCC) of Chinese cities with $GNC_a > 10\%$ in 2010 and 2016

Change ranking	City	SGNCC
1	Chengdu	2.52
2	Changsha	2.09
3	Xiamen	1.99
4	Chongqing	1.83
5	Jinan	1.81
6	Wuhan	1.55
7	Beijing	1.52
8	Hangzhou	1.48
9	Shenyang	1.45
10	Qingdao	1.40
11	Tianjin	1.38
12	Suzhou	1.36
13	Nanjing	1.31
14	Kunming	1.24
15	Dalian	1.24
16	Guangzhou	1.20
17	Xi'an	1.08
18	Hefei	0.83
19	Urumqi	0.79
20	Fuzhou	0.71
21	Shenzhen	0.56
22	Taiyuan	0.53
23	Zhengzhou	0.51
24	Taipei	0.46
25	Shanghai	0.19
26	Ningbo	0.13
27	Macao	–0.08
28	Kaohsiung	–0.25
29	Hong Kong	–0.25

up the implementation of the 'Going Global Strategy' built around a number of interlocking pivots. First, it aggressively expanded the transnational market reach of its own economy, making use of its sizable foreign exchange reserve, supportive policies for enterprises and production capacities (Breslin, 2011; Wang and Miao, 2016). Second, China government actively implemented a more outward international financial strategy, including RMB internationalization, regional monetary cooperation and reconstruction of the international monetary regime (Zhang, 2009; Woo and Zhang, 2011), to reduce the dependency on US dollar in foreign trade. By 2015, China's ODI exceeded its FDI for the first time, making the country an outbound direct foreign investor and also the second biggest in the world (Fig. 7).

Against this backdrop, Beijing's connectivity gain can to a large extent be explained by its role as a political centre (Ma and Timberlake, 2008). For example, it houses the headquarters of a large group of state-owned enterprises (SOEs) headquarters underpinning and regulating China's economic and political life. These SOEs include the 'Big Four Banks' and other 'Sino-prefixed Companies' that bear the state's imprint (Hu, 2015). Given this, Beijing serves as the platform from which the 'Going Global strategy is devised. According to the latest 'Statistical Bulletin of China's Outward Foreign Direct Investment' issued by Ministry of Commerce in 2016, there were 47 among the top 100 non-financial transnational corporations ranked by ODI stock having set their headquarters in Beijing, and 46 of them were SOEs. At the same time, only nine Shanghai corporations were on this list. In the case of the 'Big Four', this includes variegated internationalization strategies (Pan et al., 2017b) that boosts the global connectivity of Beijing in particular. Besides, the newly launched the B&R initiative will further enhance the prominence of those big scale SOEs which are involved in infrastructure, energy and finance over the short- to medium-term at least. This suggests that Beijing's role gradually moves beyond that of a national political regulatory centre to a platform that builds on this regulatory role to internationalize. From a planning perspective, there is a danger of isolating the metropolis from its local and regional role (Xiao et al., 2011).

Despite that Hong Kong remains in the top four in terms of global connectivity ranking, a negative SGNCC value suggests that Hong Kong's relative importance in articulating China into the global economy has declined. On the one hand, although Hong Kong and other leading Chinese cities serve differentiated roles in networking Chinese and global economies (Lai, 2012; Zhao, 2013), Hong Kong is increasingly facing direct competition with mainland Chinese cities, Beijing and Shanghai in particular. As a case in point, a national pilot Free Trade Zone (FTZ) was set up in Shanghai to pioneer financial reform, facilitate international trade, and attract foreign investment (Shen and Kee, 2017). Shanghai FTZ is directly modelled after Hong Kong and this new FTZ is expected to have direct impacts on Hong Kong's trading, tourism, and financial sectors (Ji et al., 2016). On the other hand, being firmly integrated into the global economy, Hong Kong is more susceptible to the lingering

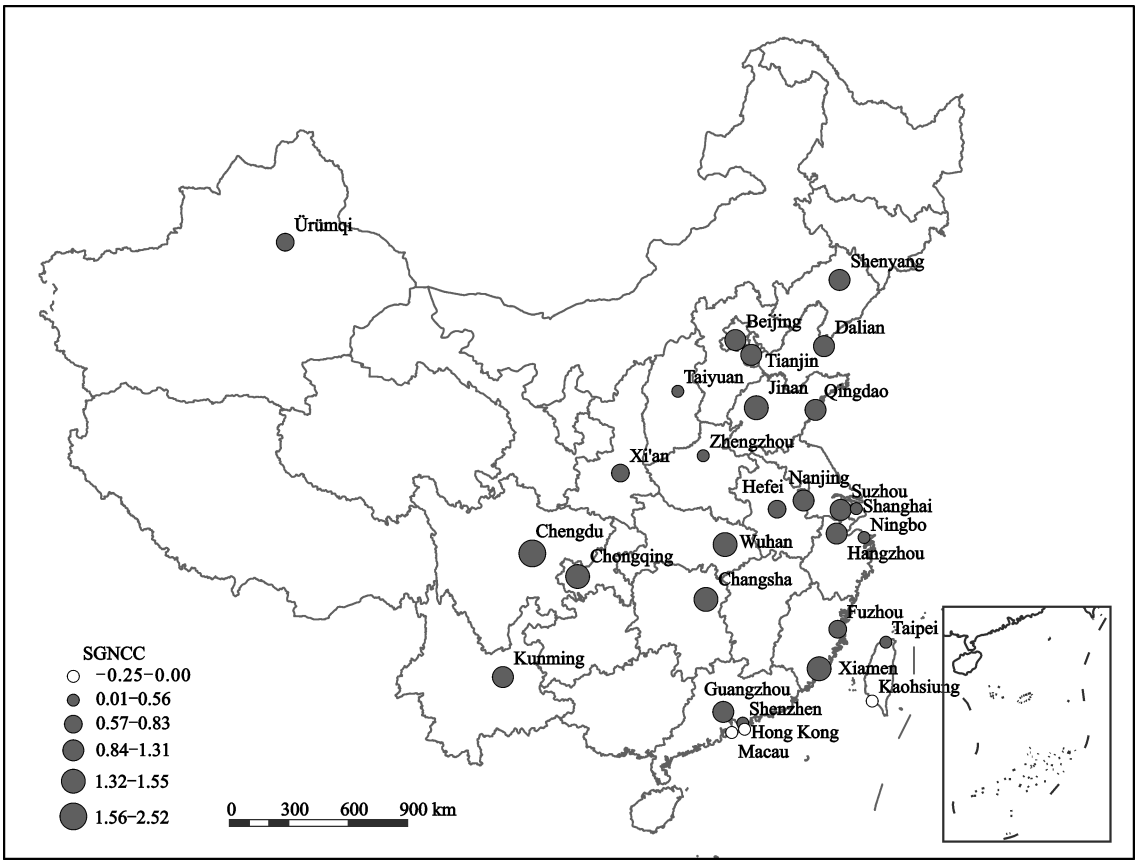

Fig. 6 Standardized global network connectivity change (SGNCC) of Chinese cities with global network connectivity (GNC_a)>10% in 2010 and 2016

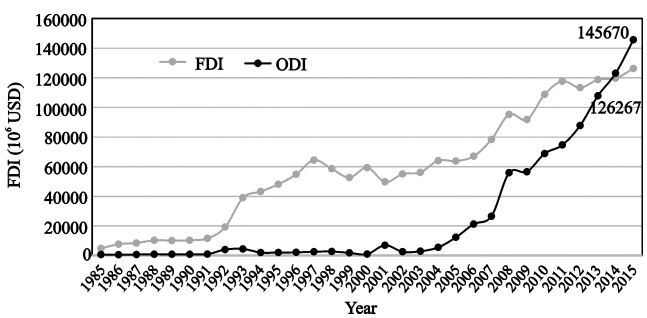

Fig. 7 Comparison between China's foreign direct investment (FDI) and outward foreign direct investment (ODI) from 1985 to 2015 (flow in 10^6 US dollars, USD). Date source: China Statistical Yearbook (2016), Statistical Bulletin of China's Outward Foreign Direct Investment (2002–2015), United Nation Conference on Trade and Development (UNCTAD) http://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx?sCS_ChosenLang=en

global economic crisis as well as the slowing growth of Chinese economy.

While Hong Kong ranks first among Chinese cities with a GNC of 74.89, its northern neighbour, Shenzhen, ranks a distant sixth with a GNC_a of 32.18. Shenzhen's SGNCC value is also relatively limited (Table 5). This is consistent with Meyer's (2016, p572) observation that, in spite of an aspiration to become an international financial centre in China, Shenzhen's advanced service industries only have 'an anomalous position in China's networks' and are shadowed by the financial sector in nearby Hong Kong. The city's aspiration for becoming an international financial centre is evidenced by the recent establishment of Qianhai financial district, another national new zone for financial innovation. However, Meyer (2016) speculates that the overall impact of Qianhai might be limited, as financial experiment zones in China such as the Shanghai FTZ also mushroom in other mainland Chinese cities.

Similar to Shenzhen, Taipei has a high overall ranking but only recorded a small gain in global connectivity. Wang (2004) observed that Taipei's role as a regional hub within the global economy is enhanced, due to Taiwan's increasingly closer economic ties to the mainland of China. However, given the more volatile cross-strait relationships in recent years and the slowing

economic growth trend of mainland China, the future trajectory of Taipei in the global urban network is open for debate. Furthermore, within Taiwan, Taipei outperforms Kaohsiung (Table 5). This is consistent with the fact that Taipei has always been a forerunner in the Taiwan's export-led economy and has a leading role in cultural, service, and financial sectors (Li et al., 2016).

Chengdu/Chongqing in the Cheng-Yu urban agglomeration and Changsha/Wuhan in Yangtze middle reach urban agglomeration, Wuhan in the middle reach of Yangtze Urban Agglomeration and Xiamen in the West Strait urban agglomeration have recorded the largest connectivity gains. As mentioned earlier, these cities appear to have been the most important beneficiaries of the nationwide rebalance strategies focusing on the large expansion of high-end businesses and industries, as well as the densification of infrastructure networks for linking their internal markets to global markets. More specifically, the rise of Chengdu in the world city network (Taylor et al., 2016) is evidenced by its connections in both infrastructure and business networks. As an anecdotal evidence, Chengdu has the fourth largest number of international connections (93 international connections as of November 2016) and undisputedly becomes the 'fourth' western pole in China's diamond-shaped aviation backbone network (with the other three poles being Beijing, Shanghai, and Guangzhou) (Li, 2012).

4 Discussion and Conclusions

The main purpose of this paper is to provide researchers with a backcloth for reference when studying the shifting position of Chinese cities in globalization. We emphasize that our approach represents but one specific vantage point in the quantitative analysis of cities in globalization. Other analytical frameworks exist in the literature, and these may or may not generate different results. Nonetheless, we believe that our approach is relevant: 1) conceptually, because the leading services firms we focus on are the key agents in the city network formation process; and 2) methodologically, because consistency in our approach allows for coherently assessing change in a city's overall 'importance'.

Examining the connectivity change between 2010 and 2016 reveals a number of trends. First, on the global scale, the shift towards Asia in general and China in particular is very visible. Although this shift is complex and variegated, it is noteworthy that with the exception of the Special Administrative Regions (SARs) (Hong Kong/Macau) and Kaohsiung of Taiwan, all Chinese cities record connectivity gains. Second, this wholesale rise in connectivity is nonetheless geographically uneven, with above all Beijing, Chengdu/Chongqing and Changsha/Wuhan becoming more connected. We interpret the former as the result of the increased internationalization of key actors in the Chinese space-economy (headquartered in Beijing), and the latter as the result of the emanation of a series of rebalancing agendas.

The 'Going Global Strategy' not only promoted the economic influence of China in the world, but also boosted a large number of Chinese cities to articulate into the WCN. Since 2014, the general 'Going Global Strategy' has been embodied into more specific and ambitious grand plans such as the B&R initiative supported by the newly founded Asian Infrastructure Investment Bank. This blueprint is aiming to leverage rising China's capabilities with respect to capital, logistics, and personnel into connecting a more integrated and innovative network for multilateral economic governance across the Eurasian and African continents (Wang and Miao, 2016). Unlike the counter current tendency on globalization within some economic bodies after the global economy crisis, this outgoing strategy of China will indeed open up more opportunities for Chinese enterprises seeking to go global. Consequently, Chinese cities along the B&R initiative will have more possibilities to gain connectivity in the WCN, not only some of the more connected cities like Shanghai and Guangzhou, but also the less connected cities that are addressed as strategic points in the plan, such as Xi'an and Ürümqi. Paralleled with these plans, other newly framed domestic nationwide spatial and economic rebalancing strategies, such as 'the Yangtze River Economic Zone', 'Beijing-Tianjin-Hebei Synergy Development Plan' and 'Yangtze River Delta Urban Agglomeration Development Plan' *etc*., will also boost more cities to articulate into the global network and seek for the advantageous positions.

Meanwhile, on the practical level, there also appears to be a race among Chinese cities to 'become a global city'. For example, in the latest city master plan approved by the NPC, Beijing is said to qualify as global city for sustainable development with social, economic and environmental balance by 2050. Shanghai has a similar ambition, as put forward in the 'Shanghai Master

Plan (2016–2040)'. It has set itself a goal to move from a 'four-tiered centre' (i.e., an international economic centre, an international financial centre, an international shipping centre and international trade centre) to 'a global city that is capable of coordinating resource use, is competitive, and that pursues excellence'. Meanwhile, the 'Wuhan 2049 strategic plan' envisions building Wuhan as a global city with significant international influence. Although these plans are consistently vague, boosterish and probably over-aspirational, they are at least partly rooted in a reality of rising connectivity. However, we have also seen that there is above all stability at the apex of the world city network, with New York and London on top, continuing to hold on to their unrivalled positions. Visions of Chinese cities being well connected are therefore realistic, but it seems likely that this will lead to a more polycentric and balanced pattern rather than a network dominated by Chinese cities.

Appendix Table City codes

Code	City	Code	City	Code	City	Code	City
AA	Amman	CT	Cape Town	LG	Lagos	RJ	Rio De Janeiro
AB	Abu Dhabi	CV	Cleveland	LH	Lahore	RM	Rome
AC	Asuncion	DA	Dallas	LJ	Ljubljana	RT	Rotterdam
AD	Adelaide	DB	Dublin	LM	Lima	RY	Riyadh
AK	Auckland	DE	Dar es Salaam	LN	London	SA	Santiago
AL	Almaty	DH	Doha	LS	Lusaka	SB	St Petersburg
AM	Amsterdam	DK	Dhaka	LX	Luxembourg	SC	San Jose (US)
AN	Antwerp	DR	Durban	LY	Lyon	SD	San Diego
AR	Ankara	DS	Düsseldorf	MA	Muscat	SE	Seattle
AS	Athens	DT	Detroit	MB	Mumbai	SF	San Francisco
AT	Atlanta	DU	Dubai	MC	Manchester	SG	Singapore
AU	Austin	DV	Denver	MD	Madrid	SH	Shanghai
BA	Buenos Aires	ED	Edinburgh	ME	Melbourne	SI	Santo Domingo
BB	Brisbane	FR	Frankfurt	MG	Managua	SJ	San Jose (Costa Rica)
BC	Barcelona	GE	Georgetown	MI	Miami	SK	Stockholm
BD	Budapest	GL	Glasgow	ML	Milan	SL	St Louis
BE	Belgrade	GN	Geneva	MM	Manama	SN	San Juan
BG	Bogota	GO	Gothenburg	MN	Manila	SO	Sofia
BI	Bristol	GT	Guatemala City	MO	Monterrey	SP	Sao Paulo
BJ	Beijing	GU	Guadalajara	MP	Minneapolis	SS	San Salvador
BK	Bangkok	GY	Guayaquil	MS	Moscow	ST	Stuttgart
BL	Berlin	GZ	Guangzhou	MT	Montreal	SU	Seoul
BM	Birmingham (UK)	HB	Hamburg	MU	Munich	SY	Sydney
BN	Bangalore	HC	Ho Chi Minh City	MV	Montevideo	SZ	Shenzhen
BO	Baltimore	HK	Hong Kong	MX	Mexico City	TA	Tel Aviv
BQ	Baku	HL	Helsinki	NC	Nicosia	TB	Tbilisi
BR	Brussels	HN	Hanoi	ND	New Delhi	TE	Tegucigalpa
BS	Boston	HS	Houston	NR	Nairobi	TJ	Tianjin
BT	Beirut	HY	Hyderabad (India)	NY	New York	TK	Tokyo
BU	Bucharest	HZ	Hangzhou	OK	Osaka	TL	Tallinn
BV	Bratislava	IL	Islamabad	OS	Oslo	TM	Tampa
CA	Cairo	IS	Istanbul	PA	Paris	TP	Taipei
CC	Calcutta	JB	Johannesburg	PE	Perth	TR	Toronto
CD	Chengdu	JD	Jeddah	PH	Philadelphia	TU	Tunis

Continued table

Code	City	Code	City	Code	City	Code	City
CG	Calgary	JK	Jakarta	PL	Port Louis	VA	Valencia (Spain)
CH	Chicago	KA	Kampala	PN	Panama City	VI	Vienna
CI	Cincinnati	KC	Kansas City	PO	Portland	VN	Vancouver
CL	Charlotte	KL	Kuala Lumpur	PR	Prague	VS	Vilnius
CM	Colombo	KR	Karachi	PT	Porto	WC	Washington
CN	Chennai	KU	Kuwait	PU	Pune	WS	Warsaw
CO	Cologne	KV	Kiev	PX	Phoenix	ZG	Zagreb
CP	Copenhagen	LA	Los Angeles	Q'D	Qingdao	ZU	Zurich
CR	Caracas	LB	Lisbon	QU	Quito		
CS	Casablanca	LE	Leeds	RI	Riga		

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