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RESEARCH ARTICLE

A comparative study of Beijing and three global cities: A perspective on urban livability

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Abstract A so-called global city that plays an important role in regional and global economic, political and cultural development should perform well in terms of its livability. The livability level of Beijing was compared with those of three acknowledged global cities, i.e., New York City, Greater London, and Tokyo-to to clarify whether Beijing has great potential to grow into a global city. From the aspects of social development, living standard and environmental quality, the livable level integrated index (*LLII*) was established in this paper to evaluate the urban livability, while the linear weighted sum was applied as the assessment model. After analyzing the situations of the four cities during 2000–2009, it was indicated that the *LLIIs* of Beijing, New York City, Greater London, and Tokyo-to were respectively 38.76, 52.93, 50.95, and 40.65 in 2000. By comparison, the *LLIIs* in 2009 were 38.96, 59.23, 69.24 and 52.15, respectively. Further analysis showed that a big gap exists between the environmental quality of Beijing and those of three global cities and the performance of social development for Beijing declined in the last decade. To accelerate the transformation of Beijing to a global city, much more attention should be paid to improve the environmental quality, especially the atmospheric quality and water quality.

Keywords global city, urban livable level, Beijing, New York City, Greater London, Tokyo-to

1 Introduction

The phrase ‘global city’ was originally coined to describe big cities in which masses of the world’s most important businesses were conducted (Geddes, 1915). At that time, global city was regarded as the strategic center that harmonized and controlled the international economy, just as the three acknowledged global cities–New York City, Greater London, and Tokyo-to have functioned. In the subsequent decades, political, economic (Friedmann and Wolff, 1982; Friedmann, 1986), financial, innovative (Sassen, 1991), human resources (Beaverstock, 1994; Beaverstock, 2002), and cultural (Nagel, 2005) profiles were all added as the important elements of global cities when a systematic study on global cities was developed in the 1960s. Among all factors, it was implied that the connectivity and influence in the urban system around the world was the key characteristic of global cities (Beaverstock and Taylor, 1999), which could represent the situations of economy, politics and culture of global cities. However, the livability has become an essential factor of global cities especially when the urban infrastructure is well developed and the environmental quality is becoming an increasing concern. On one hand, the livability indicates the strong urban influence and attraction. On the other hand, the livability will further strengthen the urban connectivity and influence by capturing more investment, human and cultural resources. Therefore, the study on global cities will be extended to the aspect of urban livability in this paper.

With rapid economic development and enlarging international impact of China, it has been widely concerned if its capital, Beijing, would be built into a modern global city (Li and Lu, 2002), especially after China’s accession into the World Trade Organization (WTO) and Beijing’s holding the 2008 Olympic Games. Global city has also been oriented as one of the objectives of the urban planning for Beijing during 2004–2020. It is recognized and approved that the international influence of Beijing on global economy and politics has increased sharply in recent years. It means that the distance between Beijing and acknowledged global cities has been shortened in a certain degree (Chu, 2010). However, according to the authoritative investigation conducted by the British Economist Intelligence Unit in 2010, Beijing did not

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appear in the list of livable cities whereas New York City, Greater London, and Tokyo-to were all livable cities (Research Group in Institution of Capital Socioeconomic Development, 2010). Admittedly, there is still a great gap between Beijing and acknowledged global cities in light of urban livability (Zhou, 2007; Wan, 2010).

A comparative study focusing on urban livability between Beijing and three acknowledged global cities was conducted in this paper. First, the framework of integrated indicator system was put forward and then the weighted sum assessment model was established. What follows were the assessment results and in-depth discussions, based on which, the limiting factors of urban livability were identified and related improvement measures were suggested so as to promote the process of constructing Beijing into a global city.

2 Methodology

2.1 Livable level integrated index system

To evaluate the urban livability, the livable level index needs to be established first, in which such basic principles of choosing indicators as dynamics and operability should be complied with (Zhang and Zheng, 2007). According to the above-mentioned key characteristics and roles of global cities (Sassen, 1991; Nagel, 2005) as well as the principles of choosing indicators, the livable level integrated index (*LLII*) was preliminarily established by referring to the related urban livability and sustainability indicators (Ng and Hills, 2003; Kang and Xu, 2010; Mai, 2010; Vogel et al., 2010). In the following part, the indicator system was slightly adjusted according to the availability and accuracy of data collected from the yearbook, statistical survey, and government official website, in which these comparable indicators denoting the situations of economic development, social security, health condition, quality of life, basic services, water quality, air quality, and resource and usage were finally selected. As listed in Table 1, the confirmed urban livability was described by 21 indicators from aspects of social progress, living level and environmental quality.

2.2 Linear weighted sum assessment model

Among such evaluation methods for urban ecosystems as linear weighted sum, fuzzy comprehensive assessment,

Table 1 Indicator system for urban livability

Objective layer	Criteria layer	Factor layer	Indicator layer	Weights
Livable level integrated index (*LLII*)	Social progress	Economic development	Per capita GDP/USD	0.0625
			Proportion of tertiary industry in GDP/%	0.0125
		Social security	Population density/($km^2 \cdot capita^{-1}$)	0.0236
			Registered unemployment rate in urban area/%	0.1433
			Deaths per 10000 vehicles from motor vehicle accidents	0.0581
		Health condition	Infant mortality/‰	0.0327
			Life expectancy	0.0163
	Living level	Quality of life	Per capita disposable income/USD	0.0763
			Per capita usable space of houses in urban areas/m^2	0.0156
			Time taken to travel to work/min	0.0410
			Engel coefficient of urban households/%	0.0290
		Basic services	New enrollments per 1000 population in colleges & universities	0.0173
			Certified physicians per 1000 population	0.0639
			Number of libraries	0.0078
	Environmental quality	Water quality	COD discharge volume per 10000 USD of GDP/kg	0.1286
			Rate of waste water disposed/%	0.0428
		Air quality	Daily mean of sulfur dioxide/($mg \cdot L^{-1}$)	0.0280
			Daily mean of nitrogen oxides/($mg \cdot L^{-1}$)	0.0509
			Annual mean of PM_{10}/($mg \cdot L^{-1}$)	0.0925
		Resource and usage	Consumed water per 10000 USD of GDP/m^3	0.0476
			Per capita park green areas/m^2	0.0095

data envelopment analysis, principal component analysis, the linear weighted sum is the most popular and effective assessment method due to its simplicity, operability, and multi-scale description (Huo et al., 2006). The linear weighted sum model is applied to evaluate and compare the urban livable levels of Beijing and three acknowledged global cities based on the *LLII*. Concrete steps of using linear weighted sum model to assess the urban livable level are given as follows.

2.2.1 Indicator normalization

Normalization was performed to unify the units of various indicators and eliminate the impact caused by different orders of magnitude. For the positive indicators that express better livable level with larger indicator value, the maximum normalization was conducted:

$$F_i = \frac{X_i}{X_{\max}}, \quad (1)$$

where F_i is the standardized value of the ith index, X_i is the ith original value of the ith index, and $X_{\max}$ is the maximum value of the ith assessing index.

For the negative indicators that express weaker livable level with larger indicator value, the minimum normalization was applied:

$$F_i = \frac{X_{\min}}{X_i}, \quad (2)$$

where $X_{\min}$ is the minimum value of the ith index.

2.2.2 Weighted sum model

After comparing the feature of the usual methods of weighting indicators including the Least Square Method (Li, 2007), Correlation Coefficient Method (Wang et al., 2003), Delphi Method (Yang et al., 2008), and Analytic Hierarchy Process (AHP), the AHP method was applied to determine the indicators' weights. According to the fixed steps, i.e., establishing hierarchical structure to represent the characteristics of system, constructing judgment matrix, and ordering layers and testing consistency (Zhao et al., 1986), the indicator weights on different layers (criteria layer, factor layer, and indicator layer) can be defined. And the weights of concrete indicators were displayed in Table 1. The quantitative assessment of urban livable level can be conducted when we finish indicator normalization and calculating indicators' weights.

1) Indicator layer

$$VI_i = F_i\omega_i \ (i = 1, 2, ..., 21), \quad (3)$$

where VI_i is the evaluation value of the ith indicator, and ω_i is the weight of the ith indicator relative to its higher factor layer.

2) Factor layer

$$VF_j = \sum_{i=1}^{n} VI_i\omega_j \ (j = 1, 2, ..., 8), \quad (4)$$

where VF_j is the evaluation value of the jth factor, n is the number of indicators belonging to the jth factor, and ω_j is the weight of the jth factor relative to its higher criteria layer.

3) Criteria layer

$$VC_k = \sum_{j=1}^{m} VF_j\omega_k \ (k = 1, 2, 3), \quad (5)$$

where VC_k is the evaluation value of the kth criteria, m is the number of factors belonging to the kth criteria, and ω_k is the weight of the kth criteria relative to its higher objective layer.

4) Objective layer

The final *LLII* is denoted by the following formula:

$$LLII = \sum_{k=1}^{3} VC_k \ (k = 1, 2, 3). \quad (6)$$

3 Results and discussion

3.1 Comparison of *LLII* between Beijing and three global Cities

The final assessment results of urban livable levels for Beijing and three acknowledged global cities, i.e., New York City, Greater London, and Tokyo-to, were obtained based on the established integrated index and linear weighted sum model. As indicated in Figs. 1 and 2, it is obvious that the integrated livable levels of New York City and Greater London were higher than those of Tokyo-to and Beijing. Specifically, the values of *LLII* for New York City, Greater London, Tokyo-to and Beijing were 52.93, 50.95, 40.65 and 38.76 in 2000, respectively. And along with the social progress and economic development, the values increased to 59.23, 69.24, 52.15 and 38.96 in 2009, respectively.

It can be found that the livable level of New York City increased stably during 2003–2007 but has begun to decrease since 2008, which may be due to the extensive influence of the world financial crisis. Comparably, the livable level of Greater London increased sharply during 2003–2004 and continued to increase steadily subsequently. The situations of Beijing and Tokyo-to were more similar to each other when compared with those of two other cities. Although the livable levels of Beijing and Tokyo-to both grew steadily during most of the study period, and even the annual average growth rate of Beijing (4.10%) was higher than that of Tokyo-to (2.52%) during

Fig. 1 Values of *LLII* for four cities during 2000–2009

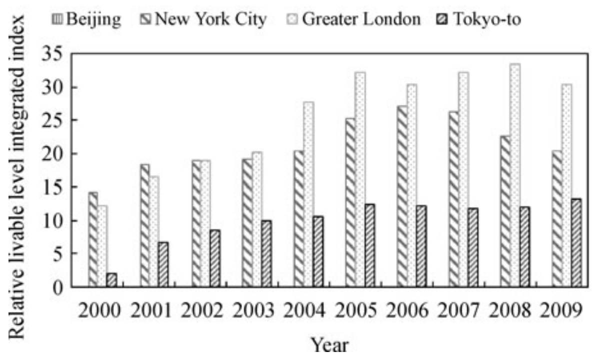

Fig. 2 Relative values of *LLII* during 2000–2009 (based on the situation of Beijing)

2000–2009, the integrated livability of Beijing was still lower than that of Tokyo-to due to the sharp decline of Beijing's livable level during 2000–2002.

3.2 Comparison of criteria layer of *LLII* between Beijing and three global cities

3.2.1 Social progress

The situation of Beijing was different from those of other cities in terms of social progress (Fig. 3). For New York City, Greater London, and Tokyo-to, the values of their social progress generally increased throughout most of the study period. Especially for Tokyo-to, the value kept an annual average growth rate of 2.71% and finally reached 57.52 in 2009, which was 1.32 times of the average value of other three cities in 2009. When it comes to Beijing, the value of social progress fluctuated during which the situation was the best among those of four cities in 2000, the worst during 2005–2008 and second in 2009 caused by the Olympic Games 2008.

3.2.2 Living level

With regard to the living level, the increasing trends for

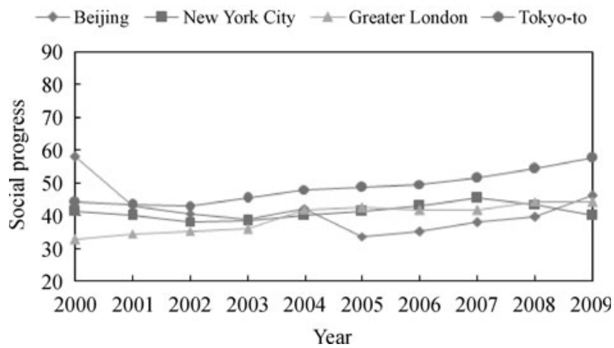

Fig. 3 Values of social progress for four cities

four cities were basically similar (Fig. 4). The annual average growth rates of living level for New York City and Greater London were 2.02% and 2.24%, respectively, while the annual value of Greater London was about 7.71 to 19.67 percent higher than that of New York City. The situations of living level for Beijing and Tokyo-to were close to each other while the values of Beijing were a little higher than those of Tokyo-to during 2000–2008 and a little lower in 2009. Finally, the value of Beijing was lower than those of New York City, Greater London and Tokyo-to by 38.29%, 46.64% and 4.5% in 2009, respectively.

Fig. 4 Values of living level for four cities

3.2.3 Environmental quality

As shown in Fig. 5, the situation of environmental quality for Beijing was worst among those of the four cities because of the late coming of environment protection in Beijing. The value of New York City, Greater London, Tokyo-to, and Beijing improved 14.22%, 45.38%, 36.45% and 62.11% during the study period, respectively. Although with the highest increasing rate attributed to the increasingly more investment for environmental protection and improvement in Beijing, the value of Beijing was only 38.36%, 31.55% and 50.92% of that of New York City, Greater London and Tokyo-to in 2009, respectively.

Fig. 5 Values of environmental quality for four cities

3.3 Identification of limiting factors for Beijing

To identify the limiting indicators that lower the urban livable level, the changing trend of criteria layer indexes for the four cities were drawn in Fig. 6. It is revealed that the situations of New York City and Greater London were similar, i.e., both of them were doing well at living level and environmental quality while remaining relatively weak in social progress. Particularly, Tokyo-to developed on these three aspects in a balanced way. With respect to Beijing, the situation of social progress improved largely during the study period while environmental quality was obviously the constraint of urban livable level all the time.

Further analysis of concrete indicators demonstrates that deteriorating water quality and air quality contributed much to the low environmental quality in Beijing. Although the water quality in Beijing improved greatly during 2000–2009, Beijing still lags behind Tokyo-to by 40.73% in 2009. Meanwhile, the air quality appeared to improve along with the 2008 Olympic Games, which quickly dropped in 2009 mainly represented by increase in daily average concentration of nitrogen oxides. It may be caused by traffic jam and excessive ownership of motor vehicle.

3.4 Potential regulation for Beijing

According to the identified limiting factors for Beijing, suitable regulation measures should be implemented to improve the environmental quality including the water environmental quality, atmospheric environmental quality, as well as resources and usage. To improve water quality, it is necessary to strengthen the construction and maintenance of the sewage treatment system, to increase the treatment capability and finally achieve a sewage treatment rate of 100%. Discharge volume of COD in urban areas should also be controlled by reforming production techniques, encouraging residents to save and protect water resources in their daily life, and strengthening monitoring of water quality. The government should

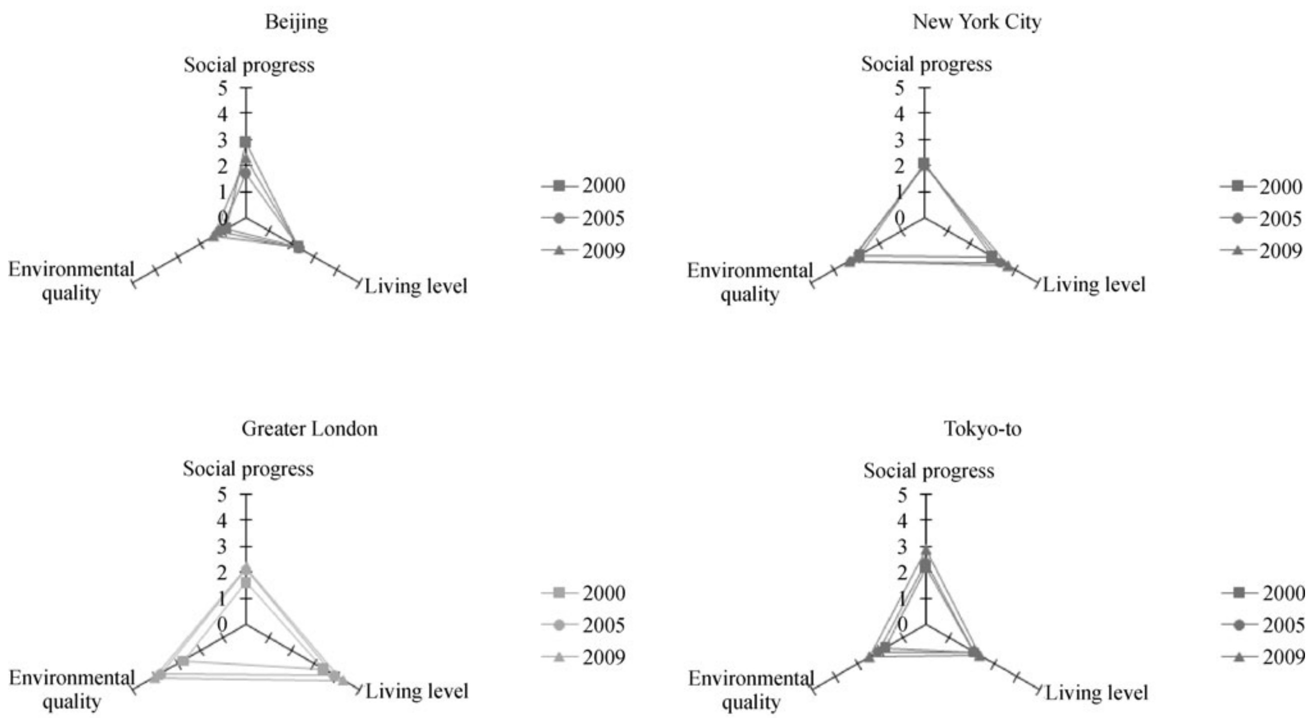

Fig. 6 Changing trend of criteria layers for four cities

devote more efforts to improving the air quality in Beijing. First, construction and protection of green area needs be strengthened to control the dust emission. Secondly, the energy usage structure should be adjusted, e.g., the policy “coal to electricity” should be promoted to control the coal-smoke pollution. Moreover, control of motor vehicle and higher waste gas emission standards are required for reducing such air pollutants as SO_2 and NO_x. To improve the situation of resources protection and reasonable usage, the government can optimize the urban greenbelts landscape, and advocate resource conservation and low-carbon lifestyle to the public.

4 Conclusions

A global city is universally acknowledged to be characterized by its connectivity and influence of the urban system. The urban livability has gradually become an alternative factor of global cities to the conventional indicator when the demand of good environmental quality gains more and more attention. Focusing on urban livability, the integrated indicator system and weighted sum model were established in this paper, based on which, a comparative study between Beijing and three acknowledged global cities–New York City, Greater London, and Tokyo-to was conducted.

Although it is recognized that the gap between Beijing and the acknowledged global cities has reduced along with the rapid economic development and social progress in China, it is concluded in this paper that the livable level of Beijing is lower than those of New York City, Greater London and Tokyo-to. There is still a long way to go for Beijing to reach the urban livable level. Of course, it also can be interpreted that Beijing has huge potential of fast catching-up, which may be referred to as late-development advantage. Regarding the identified limiting factors, corresponding regulation scheme should be conducted to improve the environmental quality in Beijing especially for water and atmospheric quality.

It should be noted that the data availability is restrained by the ‘dirty little secret’ (Short et al., 1996) and different data statistical standards among cities in different countries so that a few indicators were given up reluctantly. With more data, the urban livable level can be analyzed in more details, which can provide more useful references for construction of global cities. Meanwhile, it is necessary to keep an eye on new required indicators since the construction of global city is a dynamic process during which the human demand and concerns will change gradually. Moreover, it is suggested that Beijing adopt the internationally accepted statistical indicator with standard and start a long-term statistical program, for easy comparison with acknowledged global cities and thus adjust the developmental direction in time.

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References

Beaverstock J V (1994). Re-thinking skilled international labour migration: World cities and banking organisations. Geoforum, 25 (3): 323–338

Beaverstock J V (2002). Transnational elites in global cities: British expatriates in Singapore’s financial district. Geoforum, 33(4): 525–538

Beaverstock J V, Taylor P J (1999). A roster of world cities. Cities, 16 (6): 445–458

Chu W (2010). How far away from Beijing to global cities. Data, (4): 62–64 (in Chinese)

Friedmann J (1986). The world city hypothesis. Dev Change, 17(1): 69–83

Friedmann J, Wolff G (1982). World city formation and agenda for research and action. Int J Urban Reg Res, 6(3): 309–344

Geddes P (1915). Cities in Evolution. London: Williams & Norgate

Huo X J, Pan Y Z, Zhang L W, Qu S H (2006). The city’s ecological appraisement of sustainable development–a case study in Baotou Inner Mongolia. Journal of Arid Land Resources and Environment, 20(1): 140–145 (in Chinese)

Kang P, Xu L Y (2010). Development of ecological environment in Beijing from perspective of global city, 2010. Annual Meeting of Chinese Society for Environmental Sciences. Shanghai: 524–527 (in Chinese)

Li G P, Lu M H (2002). The preliminary research on the mode and policy tendency of Beijing constructed into a world city. Scientia Geographica Sinica, 22(3): 263–269 (in Chinese)

Li X R (2007). Compare and application of principal component analysis, factor analysis and clustering analysis. Journal of Shangdong Education Institute, 22(6): 23–26 (in Chinese)

Mai X (2010). Constructing global city based on livable city. Beijing Planning Review, (4): 178–179 (in Chinese)

Nagel C (2005). Skilled migration in global cities from ‘Other’ perspectives: British Arabs, indentity politics, and local embededdness. Geoforum, 36(2): 197–210

Ng M K, Hills P (2003). World cities or great cities? A comparative study of five Asian metropolises. Cities, 20(3): 151–165

Research Group in Institution of Capital Socioeconomic Development (2010). A Comparative study on livable level of Beijing and global cities. The Frontline, (10): 49–51 (in Chinese)

Sassen S (1991). The Global City: New York, London, Tokyo. Princeton: Princeton University Press

Short J R, Kim Y, Kuus M, Wells H (1996). The dirty little secret of world cities research: Data problems in comparative analysis. Int J Urban Reg Res, 20(4): 697–717

Vogel R K, Savitch H V, Xu J, Yeh A G O, Wu W P, Sancton A, Kantor P, Newman P, Tsukamoto T, Cheung P T Y, Shen J F, Wu F L, Zhang F Z (2010). Governing global city regions in China and the West. Prog Plann, 73(1): 1–75

Wan J (2010). Building a world city and cultivating Beijing's soft power. Municipal Administration and Technology, 12(2): 36–37 (in Chinese)

Wang Q H, Xiang R M, Yang Z L (2003). Comparison of some conventional comprehensive evaluation methods. Statistics & Information Tribune, 18(2): 30–33 (in Chinese)

Yang X H, Liu R M, Zeng Y (2008). Environmental Statistical Analysis. Beijing: Beijing Normal University Press (in Chinese)

Zhang X D, Zheng Z G (2007). Study on the environmental indicator systems of environment-friendly city. Environmental Science and Management, 32(9): 53–56 (in Chinese)

Zhao H X, Xu S B Jin S (1986). Analytical Hierarchy Process. Beijing: Science Press (in Chinese)

Zhou J L (2007). Countermeasure study of Beijing constructed into a world city. Studies on the Socialism with Chinese Characteristics, (3): 106–110 (in Chinese)