



Evaluation of Life Quality and its Spatial Mismatch with Local Economic Development in Large Chinese Cities

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Abstract

Quality of life (QoL) is an important factor which influences local economic development (LED). The study aims to evaluate the quality of life in large Chinese cities and explore the relationship between life quality and local economic development. By constructing the index system of QoL of large cities, this study analyses the spatial pattern of QoL in 39 largest cities across China and then introduces the spatial mismatch method to analyse the relationship between QoL and LED. The results point to the significant differences in QoL among large Chinese cities and unlock the spatial mismatch between QoL and LED in these cities. The quality of life is generally better than local economic development in large cities across Western China and different cities display various spatial mismatch features. This study also shows that local economic development can promote quality of life, though they do not merely stand in a quantitative relation. Quality of life is related more to the economic structure. It is suggested that future urban development focus on high value-added and environmental-friendly industries, which can improve both local economic development and quality of life.

Keywords Quality of life · Local economic development · Large Chinese cities · Spatial mismatch

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Introduction

With the acceleration of globalization, the new reconstruction of areal division of labour, and the transformation of urban governance from managerialism to entrepreneurialism (Harvey 1989; Sassen 2013), how to achieve sustainable urban growth and maintain urban competitiveness are key issues facing state and local governments. The topic also draws extensive scholarly attention. Some studies show that cities with high quality of life can attract creative classes and high-tech enterprises, which are key factors to maintaining urban growth (Rogerson 1999; Florida 2014). Many local governments have also taken quality of life as an important method of city marketing in the urban development practice (Hall 1995). This is also the case for China, which is in the late stage of accelerated industrialization and urbanization. How to maintain growth and restructure its economy has been a core issue for Chinese local governments (Office of the Central Leading Group on Financial and Economic Affairs 2015). Meanwhile, “New-type Urbanization” strategy, with emphasis on improving people’s living standards and promoting the personal development and wellbeing of individuals (State Council 2014), has been proposed and implemented by the State Council since 2014. Thus, to improve urban life quality is a new agenda in China’s urbanization.

The modern research into quality of life originate from the social indicator movement, and the basic functions of social indicators could be regarded as the instrument of monitoring social change and measuring individual and societal welfare (Noll 2002). After the development over the last five decades, quality of life has become an important interface between many disciplines, such as economics, sociology, geography and medical science. One of the key research topics in quality of life is the relationship between urban economic growth and competitiveness and quality of life.

Some studies have indicated that, besides such traditional factors as location, industrial structure, capital and technology, high quality of life, which is characterised by excellent physical environment, ideal working and living conditions and good amenities, becomes a crucial factor influencing local economic growth, as it helps sustain local business and attract inbound investment (Hall et al. 1987; Bosman and de Smidt 1993; Johnson and Rasker 1995). Some studies have also reflected that quality of life would significantly influence local economy if traditional economic factors have been satisfied, although quality of life have more impacts on the reproduction space of an area than the production space¹ (Wong 1998, 2001). Meanwhile, the theory of urban amenity holds that the success of urban development lies in the accumulation of human resources, and high life quality and good urban amenities, in this connection, contribute to local development by attracting a large number of creative class. In addition, some other studies also show that quality of life tend to influence urban development in more powerful ways when the economy is highly developed (Max-Neef 1995). Thus, the studies of western cities have shown that quality of life is related to economic development, and quality of life significantly influences local economic development.

¹ Production space refers the places or locations where the investment or business tend to distribute. Reproduction space means the places or locations where the workforce or commuters tend to move about. This reflects the potential contradictions between the production sphere of investment decisions and the social concerns of the workforce over their choice of employment and home locations.

The quality of urban life in China, the world's second largest economy and a typical developing country, has also been explored (Shek 2010). Some studies focused on the relationship between quality of urban life and local economy development in China, but the findings are at odds. Some studies show that there is a contrast between quality of urban life and rapid economic development in China, implying that economic development does not bring about high quality of life in Chinese cities (Zhang et al. 2011). However, other studies conclude that there is a positive correlation between quality of urban life and economy development in China. For instance, the studies of Song et al. (2013) and Zeng et al. (2014) both reflect that the cities with better economic performance also have higher quality of urban life. In fact, after 30 years of reform and opening-up, China's economy and life quality have been largely improved and the potential of urban development has been continuously tapped. Meanwhile, large cities are the engines for China's economic development, the competitiveness of which have also been improved in the international division of labour. As one of the main representations of urban competition, quality of life will be an important factor influencing urban development. Thus, this paper focuses on two questions: (1) What is the quality of life like in large Chinese cities? (2) Is there a relationship between quality of life and local economic development in large Chinese cities? To answer the first question, this research constructs an evaluation system. To solve the second question, this study measures the degree of spatial mismatch between quality of life (QoL) and local economic development (LED). Please note that gross domestic product (GDP) is used to indicate the performance of local economic development in this research. GDP is a monetary measure of the market value of all final goods and services produced in a period (quarterly or yearly) of time (Callen 2017). GDP estimates are commonly used to determine the economic performance of a whole country or region, and to make international or regional comparisons.

The rest of this paper is organised as follows. In Section 2, the methods and data of this study are introduced. Section 3 presents the results of spatial pattern of QoL of large Chinese cities and spatial mismatch between QoL and LED in these cities. Section 4 explains and interprets the results. In Section 5, the main findings are summarised.

Methods and Data

Evaluation Indicators of Large Chinese Cities

Quality of life reflects the well-being of individuals and societies across different dimensions or domains (Sirgy et al. 2006). There are two recognized approaches to research on quality of life: the evaluation of objective quality of life, which focuses on people's material life conditions (Smith 1973; Zolnik 2004; Higgins and Campanera 2011; Martinez 2018) and the evaluation of subjective quality of life, which explores individual's life experience and perception of happiness via surveys (Campbell et al. 1976; Diener 2000; Moore et al. 2006; Rezvani et al. 2013). However, no consensus has, to date, been reached as to whether quality of life should be limited to objective or subjective measures. Since China is a large country and the large cities are geographically distant from each other, the survey approach appears both time-consuming and cost-ineffective. As a result, this research focuses on the objective quality of life.

Defining index system and weights is crucial before any attempt to evaluate quality of life. Despite the existence of a number of index systems in studies (Hagerty et al. 2001; Marans and Stimson 2011), a good index system should be integrated, simple, comparable and feasible (OECD 2008). Thus, based on the existing studies and in the light of the realities of Chinese cities, we adopt a two-level index system in this study to better reflect the quality of life in large Chinese cities (Table 1). 8 basic aspects are considered in the first level, and each first level index is further divided into several second level indexes. Since each city differs in size, the average indicators are selected.

This research adopts two methods to determine the weights. First, the equal weights method is used to determine 8 first level evaluation index, which gives each index an equal weight 1/8. This is done based on the assumption that each dimension of quality of life is interrelated with and equally bounded by the other dimensions (Huggins 2000), and the city should satisfy individual's demands to achieve integrated human development. Related studies have displayed the validity and preferability of aggregating indicators (Huggins 2000; Savageau 2007).

Then, this paper adopts a differential weights method to determine the second level evaluation index. This is because these second level indicators are likely to correlate with other indicators within the same first level index, which leads to information redundancy. And also, the second level evaluation indicators potentially have different significance because of their own data variance. Thus, this paper adopts the CRITC (Criteria Importance Through Intercriteria Correlation) method to determine the second level evaluation index. The CRITC method is an objective method which determines the weights according to both *contrast intensity* and *conflict information* contained in the structure of the evaluation system (Diakoulaki et al. 1995).

Contrast intensity measures indicators' divergence in scores among different evaluation units. The higher value of contrast intensity means the indicator's divergence is more significant and the indicator has more information, the weight of which is heavier - and vice versa. Contrast intensity can be calculated by the methods of standard deviation, variable coefficient and entropy (Diakoulaki et al. 1995). By employing entropy method, this research calculates the contrast intensity of each second level indicator as follows:

$$e_j = - \sum_{i=1}^m p_{ij} \ln p_{ij}$$

$$g_j = 1 - e_j$$

$$\delta_j = \frac{g_j}{\sum_{j=1}^n g_j}$$

Where e_j is the information entropy of indicator j, which measures the difference of j index. g_j is the difference coefficient. δ_j is the contrast intensity of indicator j. p_{ij} is the value of indicator j in city i. In the case that cities differ greatly in their values of indicator j, e_j will be small and g_j will be big. Thus, the contrast intensity δ_j will also be big.

Conflict information is based on the correlation of each indicator, and the positive correlation means strong conflict among indicators while negative conflict means weak conflict. The conflict information is calculated as follows:

Table 1 The index system and weights of QoL of large cities in China

First level evaluation index		Second level evaluation index			Index Direction
Name	Weight	Name	CRITC Weight (ω_j)	Final Weight (W_j)	
Q1 Basic Life	0.125	Q11 Urban per capita disposable income (Yuan)	0.7847	0.0981	+
		Q12 The Engel coefficient of urban residents (%)	0.2151	0.0269	-
		Q13 General Consumer Price Index (%)	0.0002	0.0000	-
Q2 Housing Conditions	0.125	Q21 The per capita housing construction area of urban residents (m ²)	0.3703	0.0463	+
		Q22 Housing Price-to-Income Ratio	0.6297	0.0787	-
Q3 Education and Culture	0.125	Q31 The number of primary and secondary schools per square kilometre in urban build-up area	0.1997	0.025	+
		Q32 The number of full-time teachers of primary and secondary schools per 10,000 persons in urban areas	0.0199	0.0025	+
		Q33 The number of college students per 10,000 persons in urban areas	0.2798	0.035	+
		Q34 The number of books in public libraries per 10,000 persons in urban areas	0.5007	0.0626	+
Q4 Health and Medicine	0.125	Q41 The number of beds in health care institutions per 10,000 persons in urban areas	0.2225	0.0278	+
		Q42 The number of doctors per 10,000 persons in urban areas	0.1198	0.015	+
		Q43 The number of first-class hospitals per 10,000 persons in urban areas	0.6577	0.0822	+
Q5 Social Security	0.125	Q51 The registered urban unemployment rate (%)	0.3059	0.0382	-
		Q52 The number of employees in social security and social welfare per 10,000 persons in urban areas	0.2031	0.0254	+
		Q53 The proportion of insured persons in urban basic endowment insurance in total urban residents (%)	0.4909	0.0614	+
Q6 Urban Transportation	0.125	Q61 The number of buses per 10,000 persons in urban areas	0.3694	0.0462	+
		Q62 The number of taxis per 10,000 persons in urban areas	0.2314	0.0289	+
		Q63 Per capita urban road area in urban areas (m ²)	0.3926	0.0491	+
		Q64 Traffic congestion delay index	0.0066	0.0008	-
Q7 Physical Environment	0.125	Q71 Proportion of year-round days with good air quality (%)	0.8172	0.1022	+
		Q72 Green coverage rate in urban build-up areas (%)	0.1679	0.021	+
		Q73 The environmental noise equivalent level(dB)(A)	0.0148	0.0019	-
Q8 Recreation	0.125	Q81 The density of cinemas in urban build-up areas	0.1991	0.0249	+
		Q82 The density of parks in urban build-up areas	0.3221	0.0403	+
		Q83 The density of shopping malls in urban build-up areas	0.4787	0.0598	+

$$\gamma_j = \sum_{i=1}^n (1-r_{ij})$$

Where γ_j is the conflict information of indicator j , and r_{ij} is the correlation coefficient of indicator i and j within the same first level index. The higher r_{ij} is, the stronger correlation of indicator i and j will be and smaller weight they should have. Thus, the γ_j will be smaller. The Spearman correlation coefficient is used to calculate r_{ij} (Diakoulaki et al. 1995).

Thus, the CRITC weight is calculated as follows:

$$C_j = \delta_j \cdot \gamma_j$$

$$\omega_j = C_j / \sum_{i=1}^n C_j$$

Where C_j is the total information. The higher the value C_j , the larger the amount of information the indicator j contains, and the heavier its weight is. ω_j is the CRITC weight of indicator j .

The final objective weight is calculated according to the following equation:

$$W_j = 0.125^* \omega_j$$

Measurement of Spatial Mismatch

According to Rostow's (1990) Stages of Economic Growth theory, cities will finally enter the stage of "Beyond Consumption" when the economy are highly developed, meaning that life quality will be both the main goal of urban economic growth and the most significant factor impacting urban development. However, the quality of urban life does not always correspond to local economic development. Despite a number of studies into the relationship between QoL and LED, few of them explore the coherence between them from a quantitative perspective (Wong 2001; Clark et al. 2002; Rappaport 2009). Thus, this research draws on the spatial mismatch theory to explore this issue. The theory was initially proposed by Kain (1968), who studied the spatial mismatch between residential space and employment opportunities in the United States. It is argued that the spatial disconnection between the housing of blacks in the central city and availability of low-skilled jobs in suburban areas has resulted in high unemployment rates and low income of blacks, where employment opportunities of blacks have been reduced by their inability to follow jobs from the central city to the suburbs (Kain 1968, 2004). After decades of development, the theory has been enriched and is nowadays applied broadly to describe and evaluate the spatial mismatch of many other social and economic phenomena (Wei et al. 2013; Liao and Wei 2013). This research analyses the spatial mismatch between quality of life and local economic development from the following two perspectives.

Mean Centre and Standard Deviation Ellipse for the Overall Spatial Mismatch

In geometry, "spatial mismatch" refers to the spatial distributions of two closely linked phenomena, which differ in geographical space. Mean centre and standard deviation

ellipse are two commonly used indicators of the overall spatial mismatch pattern. Mean centre is based on the theory of Newton’s gravity, which identifies the geographic centre (or the centre of concentration) for a set of features. The mean centre is the point where the distribution from all directions maintains balance (Ying 2005). If the mean centres of two phenomena separate, they have spatial mismatch. The mean centre of QoL and GDP is calculated as follows:

$$S = \sum Qi^* Xi / \sum Qi, T = \sum Qi^* Yi / \sum Qi$$

$$U = \sum Gi^* Xi / \sum Gi, V = \sum Gi^* Yi / \sum Gi$$

Where, S and T are the longitude and latitude coordinates of the mean centre of QoL, Xi and Yi are the longitude and latitude coordinates of city i, Qi is the QoL score of city i, U and V are the longitude and latitude coordinates of mean centre of GDP, and Gi is the GDP score of city i. Thus, we could identify the spatial mismatch with the different mean centre of QoL and GDP. Mean centre evaluates the centralized tendency of phenomena, while standard deviation ellipse helps identify dispersion tendency (O’sullivan and Unwin 2014).

Standard deviation ellipse method summarizes the spatial characteristics of geographic features (dispersion and directional trends) through creating the standard deviation ellipse. It calculates the standard deviation of the x-coordinates and y-coordinates from the mean centre to define the axes of the ellipse (ESRI 2018). The ellipse allows researchers to see if the distribution of features is elongated and hence shows a particular orientation.

The standard deviation ellipse is given as:

$$SDE_x = \sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n}} \quad SDE_y = \sqrt{\frac{\sum_{i=1}^n (y_i - \bar{y})^2}{n}}$$

Where SDE_x and SDE_y are the x and y coordinates of the ellipse centre, x_i and y_i are the coordinates for city i, and \bar{x} and \bar{y} represents the Mean Centre for QoL or GDP of all cities.

The angle of rotation is calculated as:

$$\tan\theta = \frac{A + B}{C}$$

$$A = \sum_{i=1}^n \tilde{x}_i^2 - \sum_{i=1}^n \tilde{y}_i^2, \quad B = \sqrt{\left(\sum_{i=1}^n \tilde{x}_i^2 - \sum_{i=1}^n \tilde{y}_i^2\right)^2 + 4\left(\sum_{i=1}^n \tilde{x}_i \tilde{y}_i\right)^2} \quad C = 2\sum_{i=1}^n \tilde{x}_i \tilde{y}_i$$

Where \tilde{x}_i and \tilde{y}_i are the deviations of the xy-coordinates from the Mean Centre.

The standard deviations for the x-axis and y-axis are:

$$\sigma_x = \sqrt{2} \sqrt{\frac{\sum_{i=1}^n (\tilde{x}_i \cos\theta - \tilde{y}_i \sin\theta)^2}{n}} \quad \sigma_y = \sqrt{2} \sqrt{\frac{\sum_{i=1}^n (\tilde{x}_i \sin\theta + \tilde{y}_i \cos\theta)^2}{n}}$$

θ represents the main direction of the phenomenon distribution. The long axe and short axe represent the deviations from the mean centre on the main and secondary direction respectively. The number of standard deviations could be specified to represent (1, 2, or 3). The ellipse can be small or big correspondingly. One standard deviation will encompass approximately 68% of all features. Two standard deviations will encompass approximately 95% of all features, and three standard deviations will cover approximately 99% of all feature centroids. A separation in the standard deviation ellipses of QoL and GDP points to a spatial mismatch between two phenomena. Besides, the specific deviation degree can be reflected by above parameters. Thus, the standard deviation ellipse could be applied to indicate the spatial mismatch between quality of life and local economic development.

Spatial Mismatch Degree of each City

To reflect the degree of spatial mismatch of each city, this research incorporates the spatial mismatch contribution degree index.

$$R_i = \frac{\frac{1}{2G} \left| \frac{q_i}{Q} G - G_i \right|}{SMI} \times 100\% \quad (5)$$

$$SMI = \frac{1}{2G} \sum_{i=1}^n \left| \frac{q_i}{Q} G - G_i \right| \quad (4)$$

R_i is the spatial mismatch degree of city i . q_i is the ranking of life quality in city i . Q is the sum of all cities' life quality ranking. G_i is the ranking of GDP in city i . G is the sum of all cities' GDP ranking. SMI is the overall spatial mismatch index. The higher R_i is, a greater spatial mismatch degree the city has. This research accesses the spatial mismatch significance of each city according to the value of R_i .

If $R_i > 0.02$, which means spatial mismatch contribution degree ranks top 19, then spatial mismatch is significant.

If $R_i \leq 0.02$, then spatial mismatch is insignificant.

Study Area and Data

This study focuses on the most developed and highest administrative level cities in China, which includes 4 municipalities,² 27 provincial capitals (except Lhasa and Taipei), 4 cities specifically designated in the state plan and 4 other most developed cities (Table 2). In 2014, the GDP of these 39 large Chinese cities accounted for 39% of China's total GDP, and permanent resident population made up 25.22% of the country's total population. The average urbanization rate was 69.87% (54.77% of China). The per capita GDP of these 39 cities was \$15,603,³ implying that these cities reached the level

² The municipality is directly under the central government and has the same administrative level as the provinces.

³ Dollar currency rate was calculated according to average exchange rate in 2014.

This number ranked 49th in *World GDP (nominal)* per capita Ranking by IMF <http://statisticstimes.com/economy/world-gdp-capita-ranking.php>

of middle-income country in economic terms. Thus, these cities represent the level of quality of life in many large Chinese cities, and their features and problems can also be of future reference to other cities.

The geographical administrative data were obtained from the website of National Geomatic Centre of China (NGCC). The data of quality of life indicators were mainly derived from both *China City Statistical Yearbook 2015* and the statistical yearbook and statistical bulletin on social development by each city. The data of air quality and environmental noise were sourced from the environmental conditions bulletin of each city. The crawler software was adopted to catch the POI (Point of Interest) data from the website of Baidu Map and Dianping.com.⁴ Data for traffic congestion delay index were taken from *China's major cities' traffic analysis report in 2015* (Amap 2015). Housing Price-to-Income Ratio was calculated according to method used in *Ranking 35 Large and Medium-Sized Cities in China According to Price-to-Income Ratio* (E-house China R&D Institute 2015).

Results

The Quality of Life in Large Chinese Cities

Based on the results about life quality, this paper divides these large cities into 4 categories according to “average score + standard deviation”, “average score” and “average score - standard deviation” (Table 2 and Fig. 2). It is apparent that the 39 large Chinese cities differ significantly in terms of life quality. Guangzhou, Shenzhen, Beijing, Ningbo and Shanghai are ranked the top 5 among all cities. Lanzhou, Xining, Chongqing, Shijiazhuang, Taiyuan and Hefei have the lowest scores in urban life quality. It is also obvious that cities with higher quality of life are mostly located in the eastern part of China, and cities with low performance are nearly in western and central parts (Tab.2 and Fig. 2). The spatial pattern is similar to the economic spatial difference across China.

- 1) Cities with highest quality of life. Except Ningbo, they are also the most economically developed cities in China. All of them have at least three first-level evaluation indexes ranking among the top 5. Guangzhou, Shenzhen, Beijing and Shanghai score high in Q1 Basic Life and Q3 Education and Culture, implying that people there earn more and their children can have access to better education. This is probably the important reason why so many Chinese stream into these cities today. However, these four cities perform poorly in Q2 housing conditions, which are the main obstacles to ensuring a better life there. Meanwhile, the health conditions of Shenzhen, urban transportation of Shanghai and physical environment in Beijing are poor, a fact deserving more attention in future urban development.
- 2) Cities with second highest quality of life. Hangzhou, Suzhou and Wuxi in the Yangtze River Delta region have a high ranking in Q1 Basic Life, indicating that the urban economies are developed in these cities. However, the low health care

⁴ <http://map.baidu.com/>
<http://www.dianping.com/>

Table 2 The categories, scores and clustering results of QoL of large cities in China

NO.	Cities	Rankings of QoL									QoL Scores	Area	Category
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	QoL			
20b	Guangzhou	8	31	5	4	5	25	13	2	1	0.5430	E	I
21c	Shenzhen	9	39	2	39	4	1	2	1	2	0.5379	E	I
1a	Beijing	7	38	1	1	2	14	29	22	3	0.5019	E	I
15c	Ningbo	5	27	29	35	1	33	11	3	4	0.4749	E	I
2a	Shanghai	2	36	3	3	28	35	15	23	5	0.4529	E	I
14b	Hangzhou	3	34	11	22	3	34	25	10	6	0.4479	E	II
37b	Kunming	20	11	28	19	11	6	3	12	7	0.4471	W	II
8b	Dalian	18	26	8	20	18	10	12	6	8	0.4425	E	II
19b	Changsha	12	1	18	13	15	19	26	9	9	0.4418	M	II
39b	Dongguan	15	33	4	33	6	2	19	30	10	0.4226	E	II
12d	Suzhou	1	18	35	37	16	27	22	4	11	0.4191	E	II
13d	Wuxi	4	5	39	36	9	22	30	5	12	0.4170	E	II
10c	Qingdao	13	10	32	28	12	11	17	16	13	0.4053	W	II
22b	Xi'an	14	4	9	5	31	31	27	25	14	0.4052	E	II
9b	Jinan	10	6	6	10	7	12	39	26	15	0.3977	E	II
31b	Yinchuan	31	3	38	31	22	5	14	7	16	0.3951	W	II
7b	Shenyang	22	7	17	7	10	17	33	28	17	0.3917	E	II
28b	Fuzhou	21	35	30	21	13	20	5	8	18	0.3914	E	II
17b	Wuhan	19	19	7	15	19	16	34	19	19	0.3842	M	II
16c	Xiamen	11	37	25	38	17	15	4	11	20	0.3793	E	III
23b	Chengdu	23	13	15	9	25	18	28	17	21	0.3792	E	III
29b	Nanchang	27	16	16	30	26	24	10	14	22	0.3783	M	III
11b	Nanjing	6	28	27	17	21	26	32	20	23	0.3774	E	III
6b	Changchun	25	14	20	14	30	3	23	29	24	0.3728	E	III
34b	Nanning	34	20	10	24	24	32	7	15	25	0.3717	W	III
18b	Zhengzhou	26	21	22	11	8	36	37	13	26	0.3594	M	III
38b	Foshan	17	25	26	32	20	38	16	21	27	0.3547	M	III
5b	Haerbin	29	8	21	6	37	13	24	31	28	0.3528	E	III
35b	Haikou	33	29	33	27	14	37	1	32	29	0.3417	E	III
3a	Tianjin	24	22	13	2	33	21	35	39	30	0.3359	E	III
32b	Urumchi	35	23	36	16	35	7	8	34	31	0.3267	W	III
36b	Guiyang	37	9	24	29	27	30	6	36	32	0.3253	W	III
26b	Hohhot	16	2	37	34	39	9	21	33	33	0.3244	M	III
33b	Xining	39	15	31	23	23	4	18	24	34	0.3206	W	IV
25b	Taiyuan	30	32	19	8	29	23	31	37	35	0.3152	M	IV
27b	Hefei	28	24	23	26	34	8	36	18	36	0.3120	M	IV
4a	Chongqing	36	12	12	12	32	39	20	38	37	0.3086	W	IV
24b	Shijiazhuang	32	17	14	18	36	29	38	27	38	0.2832	E	IV
30b	Lanzhou	38	30	34	25	38	28	9	35	39	0.2556	W	IV

 Last 10 in ranking  Top 10 in ranking

Each city's number corresponds to that in Fig. 2. a: municipality; b: provincial capital, c: city specifically designated in the state plan; d: other most developed city

E: Eastern Area M: Middle Area W: Western Area

scores appear a demerit to life quality. By contrast, Kunming, Dalian, Changsha and Dongguan have relatively balanced scores among each first level evaluation index. Xi'an, Qingdao, Jinan, Yinchuan and Shenyang have some advantages in Q2 Housing conditions.

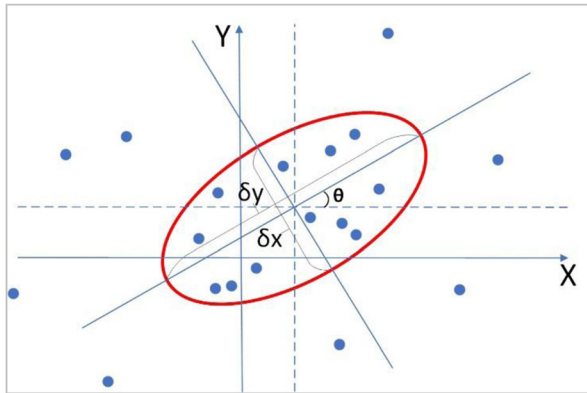


Fig. 1 Schematic diagram of the standard deviational ellipse

- 3) Cities with middle level quality of life. Although Fuzhou, Xiamen, Nanchang and Nanning have relatively good physical environment, they also display apparent shortcomings. For instance, the housing conditions in Fuzhou and Xiamen need improving, and Tianjin, Nanjing and Zhengzhou fail to have sound physical environment. Besides, Urumchi and Guiyang need to raise the standard of basic life, and the social security of Hohhot and Urumchi should be improved.
- 4) Cities with low quality of life. The general life quality in these cities is poor, and they display conspicuous problems. The basic life in Xining, Chongqing and Lanzhou are ranked among the last 5 among all cities. Taiyuan, Chongqing and Lanzhou lag behind in the parameter of Recreation. The social security in Hefei, Shijiazhuang and Lanzhou merit immediate improvement. In addition, the physical environment of Hefei and Shijiazhuang are much worse than those in other cities.

The Spatial Mismatch between Quality of Life and Local Economic Development in Large Chinese Cities

The Overall Spatial Mismatch between QoL and GDP in Large Chinese Cities

Based on the QoL and GDP scores, the mean centre and standard deviation ellipse are calculated (Fig. 3 and Table 3). A first observation reveals that the mean centres of QoL and GDP do not coincide, and neither do the standard deviation ellipses.

The mean centre reflects the centralized tendency of distribution. The places located in the same direction as the mean centre tend to have more advantages (in this research, the conditions of QoL or economic development is better). As is shown in Fig. 3, the mean centre of QoL is located to the west of that of GDP. This indicates that quality of life in large cities in Western China is comparatively better than its local economic development. The distance between two mean centres is 224 km, meaning that the spatial mismatch is significant.

Table 3 Results of mean centre and standard deviation ellipse

	Mean Centre location		Standard deviation ellipse		
	longitude	latitude	δx	δy	Rotation (θ)
QoL	113.93226	32.50913	9.147729	10.813875	59.702164
GDP	116.09943	32.153456	6.804559	9.722533	37.035279

In this research, one standard deviation is calculated when the standard deviation ellipse is generated, implying that the ellipse will encompass approximately 68% of the total scores (of GDP or QoL). A comparison of two ellipses shows that the ellipse of QoL is bigger than that of GDP. This indicates that the distribution of QoL scores is more dispersive and the disparity of life quality in large Chinese cities is smaller than that of economic development. Meanwhile, the gap between the ellipses of QoL and GDP (411 km) in Western China is much larger than that of eastern part (117 km), suggesting that more western large cities have better life quality conditions than that of local economic development.

Thus, a comparison of mean centre and standard deviation ellipse reveals that there is a real spatial mismatch between life quality and local economic development in large Chinese cities.

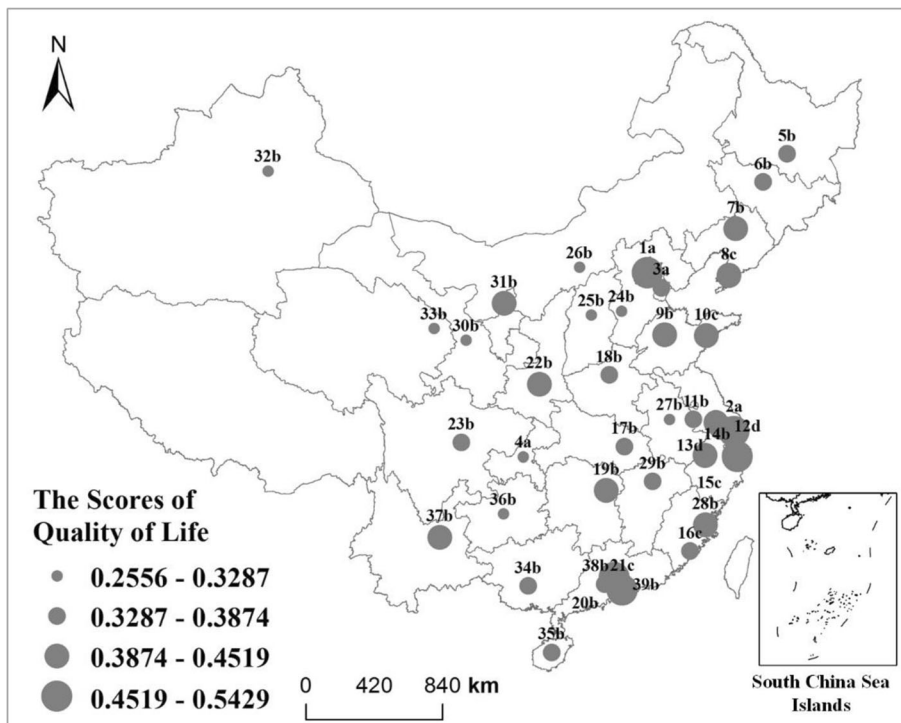


Fig. 2 Spatial pattern of QoL of large cities in China. Note: Each city's number corresponds to that in Table 2

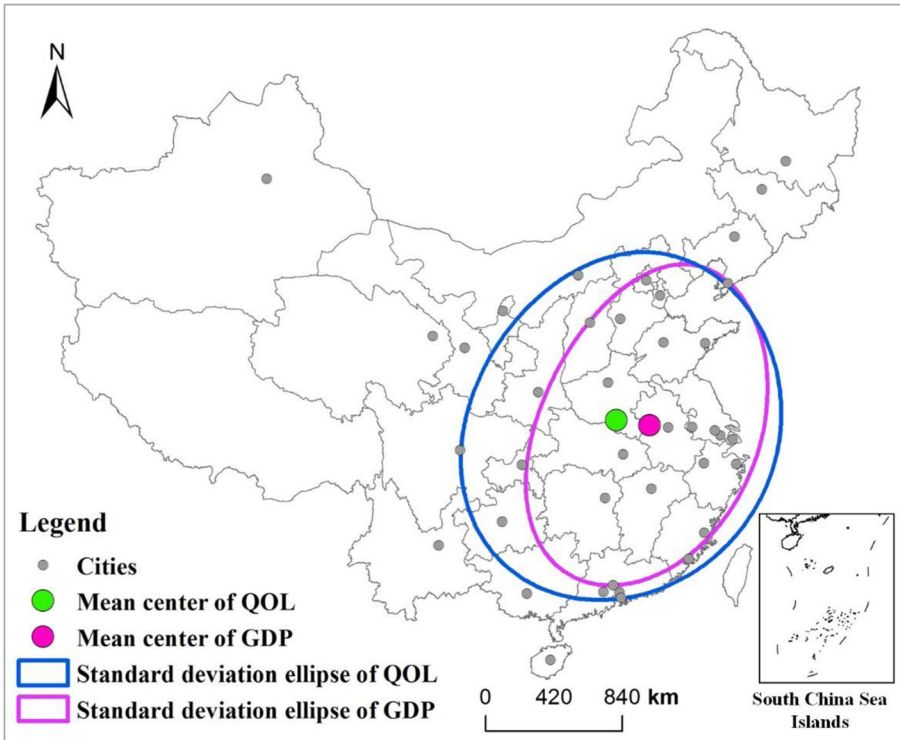


Fig. 3 The spatial mismatch between QoL and GDP of large cities in China

Spatial Mismatch Degree of each City

This study plots all the cities in Fig. 4 based on their life quality ranking, GDP ranking and spatial mismatch contribution degree index. Thus, all cities can be divided into 4 categories and 8 subcategories (Table 4).

Type I are the cities with both high life quality and economic development. Subtype I-A contains 10 cities, where the life quality and economic development are coordinated, and the spatial mismatch is not significant. Beijing, Shanghai and Shenzhen are the most representative, as their life quality and GDP are both ranked among top 5 of large cities across China. Ningbo and Dalian belong to subtype I-B, where the life quality ranking is higher than their economic development and the spatial mismatch is significant. The cities of type I not only have a developed economy but also offer prospects for high-quality life and tend to attract creative talents and enterprises, enabling them to secure distinctive edges in future urban competition.(Fig. 4 and Table 4)

Type II are the cities with high economic development yet low life quality. This type includes 7 cities, where the life quality ranking lags behind that of their GDP and the spatial mismatch is significant. Chongqing and Tianjin are the most typical cities. While their GDP are ranked 6th and 5th respectively among all large cities in China, their life quality come the 37th and 30th respectively, demonstrating a large gap between local economic growth and life quality of residents. The cities of type II mostly have a highly developed economy, and they may face bottlenecks unless the life quality is improved in future urban development.

Table 4 Categories of spatial mismatch of QoL and economic development of large cities in China

Type	Subtype	City	QoL Rank	GDP Rank	Spatial mismatch significance
I	I-A	Beijing, Shanghai, Guangzhou, Shenzhen, Suzhou, Hangzhou, Qingdao, Wuxi, Shenyang, Changsha	H	H	Not significant
	I-B	Ningbo, Dalian	H	H	Significant, QoL > GDP
II	II	Chongqing, Tianjin, Wuhan, Chengdu, Nanjing, Foshan, Zhengzhou	L	H	Significant
III	III-A	Harbin, Changchun, Hohhot, Taiyuan, Lanzhou, Xining, Guiyang, Urumchi, Nanning	L	L	Not significant
	III-B	Hefei, Shijiazhuang	L	L	Significant, GDP > QoL
	III-C	Nanchang, Xiamen, Haikou	L	L	Significant, QoL > GDP
IV	IV-A	Jinan, Fuzhou	H	L	Not significant
	IV-B	Kunming, Yinchuan, Xi'an, Dongguan	H	L	Significant

Note: The cities with significant spatial mismatch are marked in bold

Type III are the cities scoring low in both economic development and life quality. III-A covers 9 cities, where the spatial mismatch is insignificant. Quality of life and local economic development are coordinated at low levels there. The north-western

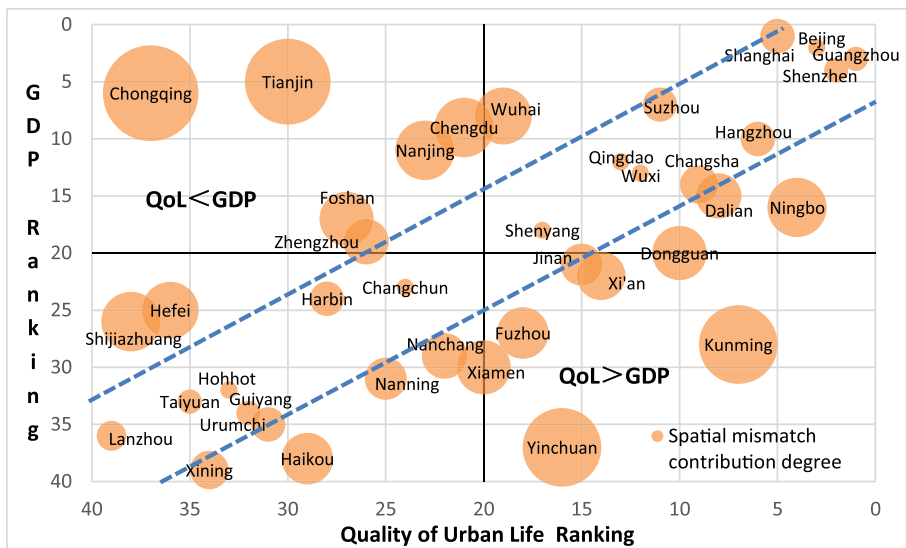


Fig. 4 Quadrifid graphic model of QoL and economic development of large cities in China. The cities outside have a significant spatial mismatch

Chinese cities of Xining and Lanzhou are most conspicuous, where life quality and economic development are both ranked among the last 5 of all cities. Hefei and Shijiazhuang fall into III-B, where their GDP ranks higher than QoL distinctly, although both indicators are at low levels. If the life quality cannot be improved, the urban development conditions will be worsening. By contrast, Xiamen, Haikou and Nanchang fall into Type III-C cities, where the life quality ranking is better than that of GDP.

Type IV are the cities with relatively low economic development yet high life quality. Jinan and Fuzhou belong to IV-A, where their life quality ranks slightly higher than GDP but the spatial mismatch is insignificant. IV-B contains includes 4 cities, where the life quality ranks higher than GDP and the spatial mismatch is significant. For example, the GDP of Kunming and Yinchuan are ranked 28th and 37th respectively, but their life quality come the 7th and 16th. If both cities make best of its advantages in life quality, urban development there will witness fast increase.

Discussion

The analysis above reveals that large Chinese cities differ significantly in terms of life quality. The results of this research also prove that there is a spatial mismatch between quality of life and local economic development.

The analysis of mean centre and standard deviation ellipse shows that the quality of life is overall better than local economic development in large cities in Western China. The main reason is that the physical environment there, as a whole, is better than that in eastern cities as a result of the presence of fewer industrial factories in the former. For example, cities such as Kunming and Xi'an are typical cities with higher quality of life yet relatively poorer economic development (Subtype IV-B in Table 4). Both are tourist cities with an enviable name in China and beyond. Kunming is located in southwestern borderland and enjoys the reputation of "Spring City" thanks to year-round spring-like climate while Xi'an is one of the reputed Four Ancient Capitals in China (the rest being

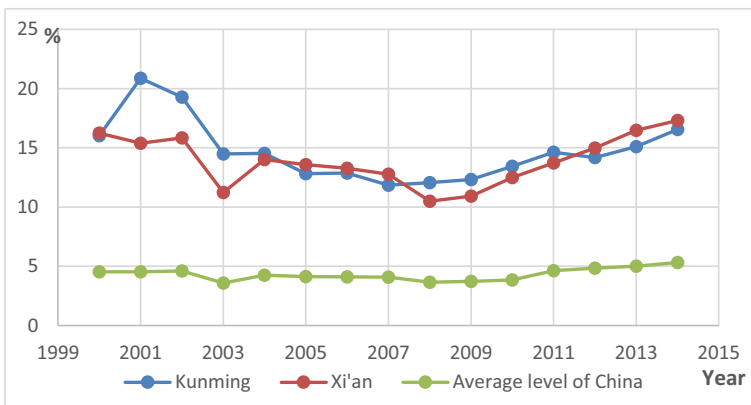


Fig. 5 Tourism revenues as percentage of GRP (Gross Regional Product) in Kunming and Xi'an

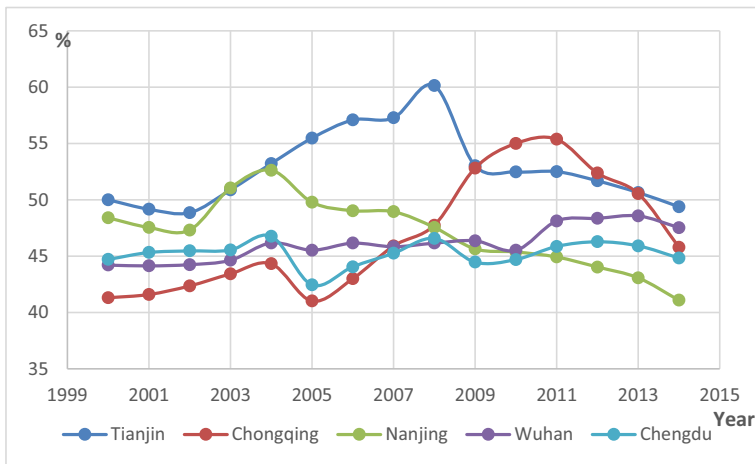


Fig. 6 Secondary industry as percentage of GDP in the five large Chinese cities

Beijing, Nanjing and Luoyang). As the former capital of Qin, Han and Tang Dynasties, it also offers tourists a window into China's long and rich historical and cultural legacies. Thus, Kunming and Xi'an are typical tourist cities in western China. Despite relatively poor industrial development in these two cities, tourism accounts for a large percentage in its GDP growth (Fig. 4).

Taking the advantage of climate and good environment, Guiyang, another southwestern Chinese city, has attracted the investment and business presence of a number of high-tech enterprises, especially big data companies. Home to the big data centre of Apple Inc., the city held the International Big Data Expo in 2015 and intends to become the country's big data centre. The number of professional employees in big data surpassed 14,000 and the GDP increased 13.9% in 2016.⁵ Drawing on the lessons from Kunming, Xi'an and Guiyang, other western cities can take advantage of its indexes of good life quality to develop tourism and attract creative class and companies to promote local economy.

Ningbo and Dalian are the typical cities (Subtype I-B in Table 4), whose QoL is significantly better than local economic development, although both QoL and local economic development are at the high levels. As the cities specifically designated in the state plan,⁶ they are generally better than ordinary large Chinese cities in economic terms. The local governments can relocate more financial resources to promote the living conditions. Meanwhile, they are also coastal cities with beaches and waterscape, which present better physical environments. Besides, compared with such megacities as Beijing and Shanghai, these cities tend to possess housing advantages due to smaller urban scale and population. These factors contribute to the superiority of QoL to economic performance.

⁵ The data is from *Guiyang statistical yearbook*

⁶ Cities specifically designated in the state plan are the cities directly managed and designated by central government. The fiscal revenue of these cities is directly given to the central government other than the provinces they belong to. These cities have more rights and freedom to dispose their incomes. Thus, the local governments of these cities are generally more rich than normal large cities.

The QoL of Xiamen and Haikou is also significantly better than local economic development, but QoL and LED are both on the relatively low levels (Subtype III-C in Table 4). Xiamen and Haikou are coastal cities with good physical environment, allowing them to stand among famous tourist cities in China. However, their city scale is notably smaller than that of other large cities. This is not conducive to both the growth of economic aggregate and infrastructure building. Thus, the basic life, education and health dimensions are relatively poorer than those in other cities, which inevitably limit the overall quality of life.

The spatial mismatch between quality of life and local economic development also reflects a contradiction between economic development and environment protection in present-day China. Chongqing, Tianjin, Chengdu, Nanjing and Wuhan are the typical cities with developed economy yet relatively poor quality of life (Type II in Table 4). They are also the traditionally industrial cities since the establishment of P.R.C in 1949. The good industrial base, especially heavy industry, has provided a substantial boost to their economy since reform and opening up. However, industrial development invariably brought about pollution. Fully aware of the importance of developing eco-friendly industries, local governments yet had no choice but to keep on developing their heavy industries to retain economic growth. For instance, the secondary industry in these five cities accounted for over 40% of its respectively GDP (Fig. 6), demonstrating that the very industry played crucial roles in local economic development. Chinese cities unavoidably face a contradiction between economic growth and environmental protection during its urban development. Out of a need for economic growth, the local government needs to maintain large-scale heavy industries, which are harmful to the natural environment. The frequently occurring smog is the nature's response to this contradiction. Faced with this dilemma, Chinese government has proposed some policies, including "adjusting economic structure and keeping growth". But the implementation effect needs to be inspected further.

Unfortunately, some traditional industrial cities, like Shijiazhuang and Hefei, still suffer from both poor QoL and LED, and the living conditions are even worse than local economic development (Subtype III-B in Table 4). Shijiazhuang and Hefei are highly dependent on high energy-consuming industry, which is detrimental to the physical environment. However, even if the physical environment is sacrificed, their secondary industries are less competitive than those in type II cities such as Tianjin and Nanjing. The reason is that their industrial mix is more concentrated in low value-added industries. As a result, their QoL and LED are both at the low levels. It is, in this connection, not reasonable nor advisable to promote economic development at the expense of the natural environment, for a highly efficient and clean industry is the key to improving both local economic development and quality of life.

Since quality of life, as a concept, is multi-dimensional, a city is likely to perform very diversely in different indicators. Even if a city ranks very high in the overall quality of life, it may perform poorly on some indicators. For example, Beijing, Guangzhou and Shanghai are among top 5 in the overall rankings. However, their housing conditions are ranked among last 10 of all cities. The reason is that the highly economically developed cities tend to have high consumer prices, especially the high housing price. In fact, these cities saw the highest real-estate prices across the country, which is a disadvantage to quality

of life. Thus, the local governments should also ameliorate their weaker dimensions even if the overall life quality ranks high.

Conclusion

This paper analyses the quality of life in 39 largest Chinese cities based on a constructed evaluation system, and the results indicate that these cities differ significantly in terms of life quality. By analysing the mean centre and standard deviation ellipse, this research proves that there is a spatial mismatch between quality of life and local economic development in large Chinese cities. Quality of life is generally better than local economic development in large western Chinese cities. Thus, these western cities can mobilize its QoL advantages to promote urban competitiveness.

The analysis of spatial mismatch degree of each city indicates that different cities display various spatial mismatch features. The life quality performance of a city can be very different from its economic performance. Cities with high QoL and LED will embrace enormous advantages in the future. Cities with poor QoL yet high LED should improve their life quality to maintain its appeal to talents and enterprises. Cities with higher QoL could make use of this advantage to increase its urban competitiveness. Cities with both low performance of QoL and LED should concentrate on either of these two development goals to resolve the dilemma. For example, they can improve the urban life quality to attract more talents, who will contribute to urban economic development.

Spatial mismatch method provides a new and useful perspective to the analysis of relationship between quality of life and economic development. This research shows that economic development can promote quality of life, though they do not merely stand in a quantitative relation. Quality of life is more related to the economic structure. High energy-consuming and pollution-inducing industries could not promote urban competitiveness but decrease urban life quality. On the contrary, high value-added and environmental-friendly industries, which could improve both local economic development and quality of life, is the direction of future urban development.

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Compliance with Ethical Standards

Conflict of Interest/Ethical Statement No conflict of interest exists in the submission of this manuscript, and manuscript is approved by all authors for publication. I would like to declare on behalf of my co-authors that the work described was original research that has not been published previously, and not under consideration for publication elsewhere, in whole or in part. All the authors listed have approved the manuscript that is enclosed.

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