QUALITY EVALUATION OF CHINESE CAPITAL CITIES′ LIVING SPACE IN 2001

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ABSTRACT: The quality dimension of the urban living space was addressed much earlier abroad; nevertheless, it has not been studied in the Chinese academia up to date, as evidenced by the limited research literature. Through recourse to Rich BOYER′s nine-factor theory, this study attempted to evaluate and rank 31 target cities, by using the data from the China Statistical Yearbook 2002. Our research results show that the quality of a city′s living space is in positive correlation with its size, and that there will be changing demands for the quality of the urban living space as a result of future social, economic, sci-tech, cultural and educational developments, combined with the improvement of the overall quality of urban residents. Previous research was focused on the quality of food, housing, education, transportation and entertainment. However, with the development of the knowledge-economy, such factors as information accessibility, green environment, and air quality, will be major considerations in the quality evaluation of the urban living space.

KEY WORDS: the nine-factor theory; urban living space; quality evaluation

1 INTRODUCTION

The term "living quality" was put forward by American economist J K CALBRITH in his book *The Affluent Society* in 1958 (PAN, 1994). However, R C WADE, an American sociologist, is generally considered the first scholar to deal with "the quality of urban living space" as a specialized area of inquiry, as evidenced by his publication in 1967, known as *Urban Life in America* (WANG Xu, 2000). Earlier relevant research may be divided into four stages: 1) budding (the early 20th century−1950s), which was featured by a rising concern about the quality of urban living environment; 2) theorization (1950s−1960s), which placed emphasis on theoretical research; 3) applied research (1970s−1980s), which was intended to establish an evaluation system and determine its validity and reliability; and 4) predication (1980s−present), which focused on quality predications of the urban living environment based on applied research findings. Up to date, overseas research on the quality of urban living space has shifted its perspective from an evaluation and prediction of eco-spatial factors to an evaluation and analysis of socio-spatial and even ecological factors. Such research findings have largely contributed to the es-

tablishment of a human-centered evaluation mechanism, thus bringing a brand-new perspective to the study of the issue under discussion(WANG Xu, 2000; WANG, 2002; SUN and WANG, 2002).

The Chinese research on the quality of urban living space dates back to the 1990s. Up until now, much research has been focused on theoretical and general discussions of the issue within the purview of our inquiry depending on the system theory, and the ecological theory and the theory of sustainable development. Applied and specific studies are relatively scanty. There are no research findings about the quality of the living environment of the 31 Chinese provincial capitals (WANG Xing-zhong, 2000; LIU, 1996). This paper makes recourse to overseas research results and makes a preliminary attempt to deal with the issue so as to provide the scientific basis for the Government to make decisions concerning the improvement of the urban living environment.

2 METHOD

2.1 Establishing Evaluation System

Up to date, the academia has set up an evaluation system, which is basically made up of two sets of in-

dexes: subjective and objective. Typical examples of objective indexes include PQLI (the physical quality of life index) and HDI (the human developmental index). These sets of indexes are socio-economically rather than socio-spatially driven; therefore, they are evidently inadequate for an overall quality evaluation of the urban living space. In contrast, subjective indexes are characteristically human-centered, and they are generally used for a quality evaluation of the living space in terms of resident satisfaction (sense of happiness).

Over the past twenty years since China's reform and opening-up, the living level of urban residents has improved steadily (Table 1). Nevertheless, most Chinese provincial capitals as a whole are only equivalent to its American counterparts of the 1980s in terms of life quality, let alone small and medium-sized ones.

Table 1 Per-capita consumption expenditures in Chinese cities (%)

	Food	Housing	Education	Transportation	Leisure and entertainment
1985	52.24	4.79	3.86	2.14	4.31
1990	54.25	6.98	4.33	1.20	6.79*
1995	50.09	8.02	4.61	5.18	4.75
2000	39.44	11.31	7.08	8.54	6.32
2001	37.68	10.35	8.21	10.38	6.75

Note: * The datum is overhigh because of the consumer emulation in 1990

Sources: National Bureau of Statistics of China, 1986, 1991, 1996, 2001 and 2002

In the 1980s, American urban socio-geographer Rich BOYER made a comprehensive evaluation of the social life quality of 333 American cities on both macro and micro levels by using the nine-factor system, which exerted an important influence on the research community in the world. Based on his research findings, we have set up an evaluative index system (Fig. 1) for evaluating the living-space quality of Chinese provincial capitals. The indexes were selected in terms of typicality, availability and temporality, and the collections of data used were taken from relevant statistical yearbooks (National Bureau of Statistics of China, 2002a, 2002b, 2002c, 2002d; China National Tourism Administration, 2002; Central Commission for Overall Administration of Public Security, 2002).

2.2 Selection of Secondary Indexes
On the basis of the nine primary factors proposed by Rich BOYER, we have selected one to three indexes, which are of maximum relevance to the primary factor with reference to the data from the relevant statistical

yearbooks 2002 (Fig. 1). The following notes are for further interpretations:

(1) The rates of death and divorce hereof are quoted from the results of the 5th national population census of the year 2000. They are somewhat different from the data of 2002, however, the source of data used for this study is the most authoritative.

(2) In consideration of what means of transportation is easily accessible to urban residents, three indexes are specified under the transportation heading: road area per capita, numbers of buses and trolleys per 10000 persons, and the number of year-end taxis.

(3) The rate of divorce and the number of criminal offenses handled are secondary indexes under the heading of social security, the latter of which can best indicate the level of social security in a given city. The July 2002 edition of China Statistical Yearbook on Social Security, from which the data are drawn, is the latest and most authoritative source of information. In spite of the marginal difference between the data used and the social reality in 2001, they are still a fairly objective indication of the level of social security in each target provincial capital.

(4) It is difficult to specify secondary indexes under the heading of access to art, because uniform sets of data are hard to obtain from the target cities as a reflection of their artistic levels. Therefore, we only referred to the yearbooks for galleries, showplaces, museums, and artistic green coverage as two sets of secondary indexes. Slight differences may exist in the former set of indexes.

(5) As far as a few cities are concerned, data are not available as secondary indexes. They are statistically labeled as "Not Available".

2.3 Data Analysis
In evaluating and comparing the 31 target cities in terms of life quality, we processed our collections of secondary-index data quantitatively. Each factor was assigned a certain weight value, and based on overseas research experience, secondary indexes were equally weighed (HARTSHORN, 1992). Each weight value was determined subjectively and objectively. We designed a nine-factor questionnaire, and conducted a sampling survey of 1300 residents in Jinan, the capital city of Shandong Province. We selected 1000 valid questionnaires for the sake of statistical convenience, and worked out a descending sequence of weight values by taking into account the effect of the nine factors on the quality of urban living space: 0.27, 0.16, 0.11, 0.06, 0.15, 0.08, 0.11, 0.04, 0.02.

The following two formulae were used for standard processing of all the raw data as presented in Table 2 to

Primary factor　　　　　　　　　　　　**Secondary index**

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Factor ─┬─ Economic situation (x₁) ─┬─ Working population (x₁₁)
        │                           └─ Yearly salary (x₁₂)
        │
        ├─ Housing (x₂) ─┬─ Housing space per capita (x₂₁)
        │                └─ Investment in real estate (x₂₂)
        │
        ├─ Health (x₃) ─┬─ Number of hospital beds per 100000 persons (x₃₁)
        │               └─ Death rate (x₃₂)
        │
        ├─ Transportation (x₄) ─┬─ Road area per capita (x₄₁)
        │                       ├─ Number of buses and trolleys per 10000 persons (x₄₂)
        │                       └─ Year-end number of taxis (x₄₃)
        │
        ├─ Education level (x₅) ─┬─ College students per 10000 persons (x₅₁)
        │                       └─ Average expenditure on education (x₅₂)
        │
        ├─ Social security (x₆) ─┬─ Number of criminal offenses handled (x₆₁)
        │                        └─ Divorce rate (x₆₂)
        │
        ├─ Climate (x₇) ─┬─ Annual average temperature (x₇₁)
        │                ├─ Annual precipitation (x₇₂)
        │                └─ Total amount of sunshine per year (x₇₃)
        │
        ├─ Entertainment facilities (x₈) ─┬─ Number of theatres per 1×10⁶ persons (x₈₁)
        │                                 └─ Per capita parkland & grassland (x₈₂)
        │
        └─ Access to art (x₉) ─┬─ Number of art galleries & museums (x₉₁)
                               └─ Status and artistic green coverage (x₉₂)
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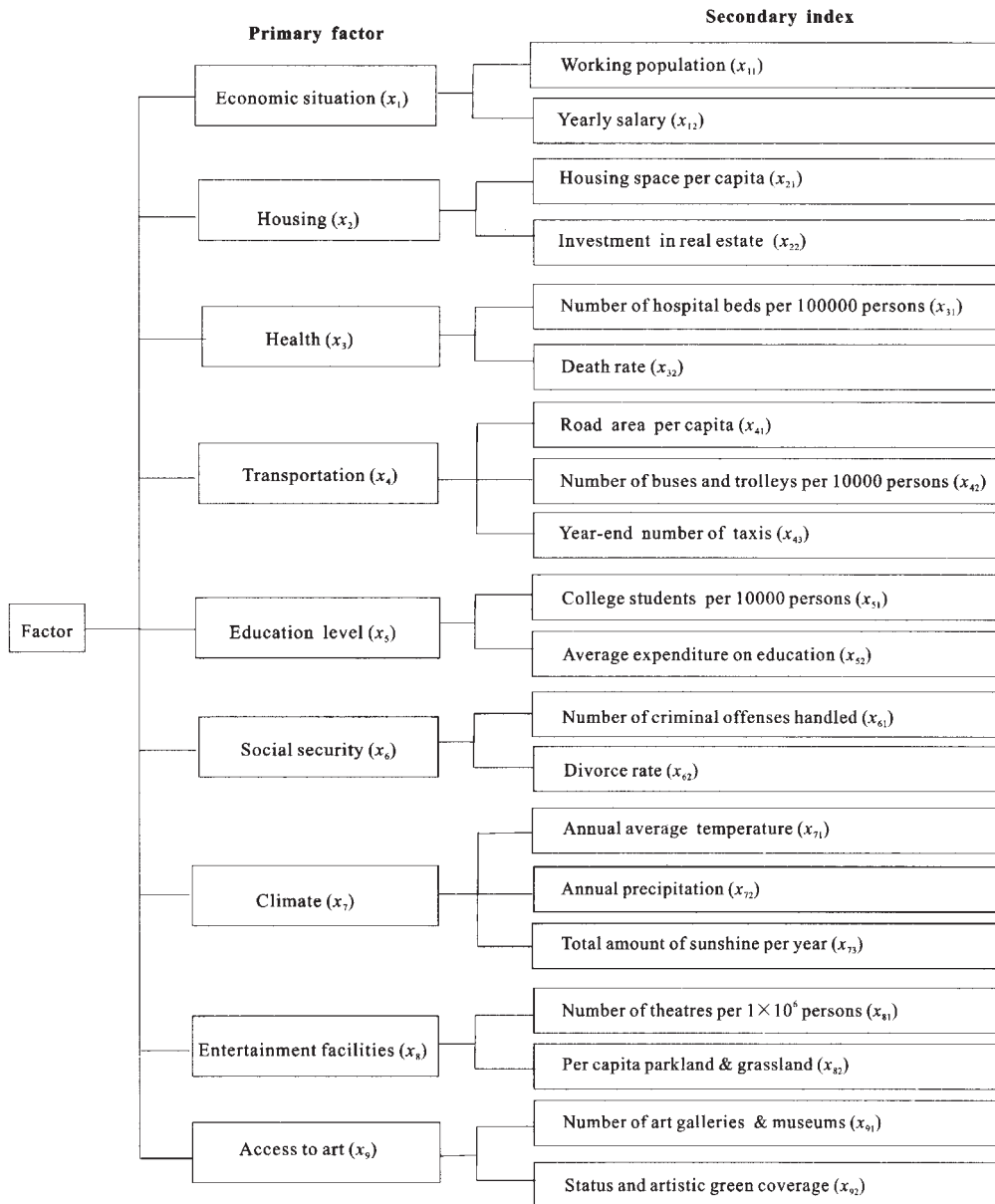
Fig. 1 Evaluation system of living space quality in contemporary Chinese cities

eliminate dimensional effects. The results are shown in Table 3.

$$y_i = \frac{x_i - \bar{x}}{s} \quad (1)$$

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

In formula (1), (2), y_i represents the standard value of ith factor; x_i, its original value, $\bar{x}$ its average value; s, its standard deviation; and n, the number of samples or the number of provincial capitals.

In evaluating and classifying the target Chinese provincial capitals in terms of the quality of the living envi-ronment, we worked out a composite index. First, we used the formula, $R = \sum_{i=1}^{n} x_{ij} \cdot Q$ to calculate the primary-factor evaluative index, where R represents the primary-factor evaluative index, x_{ij}, the secondary-index standard value, Q, the primary-factor weight value, and n, the number of secondary indexes. Second, we used the formula, $T_j = \sum_{j=1}^{m} w_j \cdot y_{ij} (i=1, 2, ..., 31, m=9)$, to calculate the composite evaluative index of the urban living-space quality, where T_i represents the total score of a given provincial capital, w_j, the primary-factor weight value, y_{ij}, the primary-factor standard value, and m, the number

Table 2   Original data of Chinese provincial cities in 2001

City	x_1		x_2		x_3		x_4			x_5		x_6		x_7			x_8		x_9	
	x_{11} (×10⁴yuan)	x_{12} (×10³)	x_{21} (m²)	x_{22} (×10⁸yuan)	x_{31}	x_{32} (‰)	x_{41}	x_{42}	x_{43}	x_{51} (yuan)	x_{52}	x_{61}	x_{62} (‰)	x_{71} (℃)	x_{72} (mm)	x_{73} (h)	x_{81}	x_{82} (m²/p)	x_{91}	x_{92}
Beijing	19.50933	6289.0	17.63	75.498	676.10	−5.30	6.11	13.10	65155	731.25	342.86	−29323	−5.12	12.9	338.9	2611.7	23.88	30.59	0.9007	37.99
Tianjin	14.45395	1923.0	17.78	16.060	499.67	−5.94	5.71	7.80	31939	440.08	205.88	−9758	−3.40	13.0	502.9	2100.7	3.74	11.86	1.0829	26.05
Shijiazhuang	14.60726	914.7	16.51	2.680	856.15	−6.18	8.36	9.52	6553	227.50	554.94	−47887	−2.31	14.4	303.2	2127.3	2.05	19.82	3.2821	34.44
Taiyuan	9.70086	855.5	14.99	2.076	774.75	−5.90	6.34	5.09	8300	144.62	423.20	−52382	−1.86	11.0	298.0	2390.2	7.11	18.45	2.1739	31.85
Hohhot	12.43908	365.4	14.60	1.529	539.12	−5.79	5.34	3.99	3959	206.08	517.13	−37758	−1.84	8.2	296.1	2636.7	1.85	23.38	4.4289	19.47
Shenyang	11.61501	1207.6	13.64	7.623	612.57	−6.10	8.22	7.36	16735	237.21	343.97	−86235	−4.56	8.4	583.8	2300.8	5.32	42.06	1.4764	22.87
Changchun	12.32732	936.0	15.18	4.070	36.07	−5.38	5.36	10.15	12537	100.71	522.83	89837	−4.32	11.5	389.9	2843.9	3.02	18.58	2.0804	38.77
Harbin	10.40314	1722.9	14.23	8.113	715.22	−5.49	3.90	10.95	11556	248.88	523.79	−68779	−5.01	6.1	385.2	2599.6	2.60	16.78	2.2447	28.73
Shanghai	26.16932	7527.6	17.30	63.073	578.69	−5.97	10.62	14.32	46921	789.60	221.77	−33542	−5.84	4.8	1276.8	1914.9	3.17	11.70	1.0054	25.78
Nanjing	17.21173	986.7	15.48	10.679	481.57	−6.62	12.28	11.73	8956	291.56	747.41	−78831	−2.34	17.2	737.3	1870.8	11.56	97.20	1.5596	42.69
Hangzhou	18.96207	834.9	–	12.556	468.26	−6.25	5.11	7.03	7232	280.27	412.70	−78943	−2.52	16.6	1566.6	1664.4	16.86	18.65	1.4757	34.68
Hefei	10.80439	429.0	–	2.528	683.07	−5.85	9.83	13.44	6500	192.26	610.07	−76000	−2.05	17.3	794.3	1662.2	15.95	25.52	3.7695	33.90
Fuzhou	13.51135	720.1	18.89	7.592	649.93	−5.52	5.93	9.51	3723	348.97	595.25	−64283	−1.98	20.6	1273.0	1631.8	7.15	22.35	4.0320	33.21
Nanchang	10.77045	567.6	14.61	1.928	596.63	−6.06	5.04	5.45	3425	116.95	655.61	−45558	−1.87	18.2	1416.5	1917.9	5.15	12.81	3.3204	27.87
Jinan	12.70935	810.2	16.63	6.025	558.44	−6.24	8.45	6.72	10700	205.50	529.80	−92045	−1.64	14.6	599.3	2314.0	7.55	15.18	1.9538	32.49
Zhengzhou	11.33275	894.4	–	4.680	777.89	−6.26	6.55	7.25	10764	197.37	746.36	−138183	−1.56	15.1	401.8	2045.2	12.23	10.21	2.3578	30.32
Wuhan	11.31448	1389.2	12.60	11.534	378.84	−6.07	2.35	7.49	12137	183.67	406.65	−72796	−1.82	18.0	899.8	2106.3	9.10	8.01	0.9760	33.56
Changsha	13.00167	624.7	15.60	4.038	818.11	−6.72	6.08	6.90	7192	155.03	938.32	−69005	−1.96	17.6	1451.5	1555.1	4.43	30.65	3.4298	28.25
Guangzhou	23.53341	1686.9	–	37.651	557.05	−5.12	10.22	11.09	16598	483.04	424.17	−58608	−4.06	22.5	2678.9	1651.0	2.95	171.84	1.3172	31.46
Nanning	11.11990	430.6	–	1.829	726.80	−6.07	7.58	6.57	3743	–	426.94	−43921	−1.87	21.3	1987.5	1337.8	5.08	35.36	3.9173	38.16
Haikou	13.05635	367.4	17.15	1.350	750.83	−5.76	10.43	13.69	2788	182.81	200.90	−6452	−1.14	24.9	2247.0	1606.9	43.19	29.17	0.9663	42.85
Chongqing	10.39908	2047.9	14.39	16.796	361.53	−6.90	4.43	4.53	14165	101.98	181.29	−48000	−3.34	18.8	814.8	1050.4	1.55	9.85	6.3334	22.09
Chengdu	13.48976	1224.4	17.75	14.912	591.21	−6.79	6.51	7.42	8425	159.95	514.05	−100862	−3.26	17.3	826.2	1065.2	3.22	12.69	2.2305	21.89
Guiyang	10.64643	538.0	15.80	4.254	555.35	−7.23	3.31	10.05	2199	166.34	400.49	−72367	−1.86	14.5	942.3	997.9	3.14	22.40	–	33.08
Kunming	12.73395	810.0	–	6.526	853.62	−7.57	4.74	14.39	7725	234.22	397.23	−86450	−2.01	16.0	1173.0	2068.7	8.36	24.64	1.3997	30.77
Lhasa	–	–	–	–	–	−6.50	–	–	–	–	–	−6322	−1.43	8.8	492.3	2819.2	–	–	0.9623	–
Xi'an	11.16447	1139.3	10.73	6.366	645.25	−6.34	4.77	6.85	10430	126.10	630.31	−38240	−2.89	15.0	405.9	1378.7	5.25	10.59	7.0915	34.21
Lanzhou	10.59019	546.5	–	2.292	668.40	−6.43	6.14	8.91	6638	169.92	489.90	−20434	−1.88	11.0	270.3	2501.9	5.35	8.16	9.4671	15.20
Xining	12.22666	220.1	9.01	1.341	725.62	−6.44	4.25	10.64	5144	179.17	186.86	−10593	−3.65	6.0	397.8	2465.2	16.69	13.06	3.2049	21.33
Yinchuan	10.95134	216.7	15.21	1.757	706.37	−4.84	7.47	8.34	4520	161.51	272.87	−1623	−2.78	10.1	163.2	2869.9	41.23	29.58	0.5426	22.77
Urumqi	12.94531	486.8	14.00	6.075	876.20	−5.69	6.92	20.05	6392	170.74	366.05	−9626	−7.24	7.7	227.7	2504.3	8.17	27.57	8.8040	24.89
Average	13.35669	1290.4	15.21	11.448	623.99	−6.11	6.61	9.34	12102	161.49	389.20	−48208	−2.88	14.2	843.3	2019.7	9.56	27.62	2.9263	30.05
Standard deviation (S)	3855.830	158.21	2.251	171.00	170.70	0.586	2.31	3.487	13254.0	7.698	64.07	40728.8	1.44	5.04	623.4	534.0	10.17	31.3	2.27	6.73

Table 3 Standard processed secondary-index data of the target Chinese cities in 2001

City	x₁		x₂		x₃		x₄			x₅		x₆		x₇			x₈		x₉	
	x_{11} (×10⁵yuan)	x_{12} (×10³)	x_{21} (m²)	x_{22} (×10⁶yuan)	x_{31}	x_{32} (‰)	x_{41}	x_{42}	x_{43}	x_{51} (yuan)	x_{52}	x_{61}	x_{62} (‰)	x_{71} (°C)	x_{72} (mm)	x_{73} (h)	x_{81}	x_{82} (m²/p)	x_{91}	x_{92}
Beijing	1.596	173.17	1.078	374.6	0.307	1.377	-0.217	1.077	4.003	74.018	-0.723	0.464	-1.552	-0.251	-0.808	1.108	1.408	0.095	-0.892	1.180
Tianjin	0.284	21.92	1.144	27.0	-0.728	0.285	-0.390	-0.443	1.497	36.190	-2.861	0.944	-0.358	-0.234	-0.546	0.150	-0.573	-0.504	-0.812	-0.595
Shijiazhuang	-0.454	-12.99	0.580	-51.3	1.360	-0.125	0.756	0.050	-0.419	8.575	2.587	0.020	0.398	0.045	-0.869	0.201	-0.739	-0.249	0.157	0.652
Taiyuan	-1.003	-15.07	-0.095	-54.8	0.883	0.353	-0.560	-1.220	-0.287	-2.191	0.531	-0.102	0.711	-0.629	-0.874	0.696	0.241	-0.293	-0.331	0.267
Hohhot	0.237	-32.07	-0.269	-58.0	-0.497	0.541	-0.550	-1.536	-0.614	5.793	1.997	0.257	0.724	-1.186	-0.880	1.153	-0.759	-0.136	0.662	-1.574
Shenyang	-0.452	-2.85	-0.695	-22.4	-0.067	0.012	0.695	-0.569	0.350	9.836	0.706	-0.934	-1.163	-1.147	-0.418	0.529	-0.417	0.461	-0.638	-1.068
Changchun	-0.267	12.28	-0.011	-43.1	-3.445	1.241	-0.541	0.231	0.033	-7.895	2.086	3.389	-0.997	-0.529	-0.730	1.543	-0.643	-0.289	-0.372	1.296
Harbin	-0.766	14.96	-0.433	-19.5	5.071	1.053	-1.173	0.460	-0.041	11.352	2.101	-0.505	-1.475	-1.604	-0.735	1.086	-0.685	-0.346	-0.300	-0.197
Shanghai	3.323	191.36	0.931	301.9	-0.265	0.234	1.733	1.427	2.627	81.593	-2.613	0.360	-2.051	-1.860	0.696	-0.195	0.196	-0.509	-0.846	-0.636
Nanjing	1.000	-10.52	0.122	-4.5	-0.834	-0.875	0.447	0.682	-0.237	16.897	5.591	-0.752	0.378	0.602	-0.173	-0.279	0.728	2.223	-0.602	1.879
Hangzhou	1.454	-15.89	–	6.5	-0.912	-0.244	-0.649	-0.665	-0.368	15.430	0.367	-0.755	0.253	0.479	1.159	-0.663	0.628	-0.287	-0.639	0.688
Hefei	-0.662	-29.87	–	-52.2	0.894	0.439	1.391	1.175	-0.423	3.997	3.447	-0.682	0.579	0.618	-0.078	-0.668	-0.237	-0.067	0.371	0.572
Fuzhou	0.040	-19.78	1.637	-22.6	0.152	1.002	-0.054	0.048	0.632	24.354	3.216	-0.395	0.627	1.276	0.691	-0.724	-0.434	-0.169	0.487	0.469
Nanchang	-0.671	-26.03	-2.643	-55.7	0.160	0.080	-0.680	-1.117	-0.655	-5.786	4.158	0.065	0.704	0.802	0.919	-0.189	-0.198	-0.473	0.174	-0.325
Jinan	0.168	-16.66	0.633	-31.7	-0.381	0.227	0.795	-0.754	-0.106	5.717	2.194	-1.076	0.863	0.084	-0.390	0.551	0.262	-0.398	-0.428	0.362
Zhengzhou	-0.537	-13.70	–	-39.6	0.902	-0.261	-0.027	-0.601	-0.101	4.661	5.574	-2.209	0.919	0.184	-0.707	0.050	-0.046	-0.556	-0.250	0.040
Wuhan	-0.530	3.40	-1.157	0.5	-1.436	0.063	-1.843	-0.532	0.003	2.882	0.272	-0.604	0.738	0.758	0.089	0.162	-0.505	-0.627	-0.859	0.521
Changsha	-0.092	-23.07	0.176	-43.3	1.137	-1.046	-0.230	-0.701	-0.370	-0.839	8.570	-0.511	0.641	0.680	0.975	-0.869	-0.650	0.097	0.222	-0.268
Guangzhou	2.639	13.75	–	153.2	-0.392	1.684	1.560	0.501	0.339	41.770	0.546	-0.255	-0.816	1.654	2.947	-0.691	-0.441	4.607	-0.708	0.209
Nanning	-0.580	-24.82	–	-56.3	0.602	0.063	0.419	-0.796	-0.631	–	0.589	0.105	0.704	1.415	1.838	-1.276	–	0.247	0.437	1.205
Haikou	-0.078	-31.95	0.864	-59.1	0.744	0.592	1.651	1.246	-0.703	2.770	-2.939	1.025	1.210	2.128	2.250	-0.774	3.307	0.049	-0.863	1.903
Chongqing	-0.767	26.25	-0.362	31.3	-1.538	-1.353	-0.943	-1.381	0.156	-7.730	-3.245	0.005	-0.316	0.919	-0.045	-1.816	-0.788	-0.568	1.500	-1.184
Chengdu	0.035	-2.30	1.131	20.3	-0.192	-1.166	-0.044	-0.552	-0.277	-0.200	1.949	-1.293	-0.261	0.618	-0.028	-1.788	-0.624	-0.477	-0.306	-1.214
Guiyang	-0.703	-26.08	0.264	-42.1	-0.402	-1.916	-1.428	0.202	-0.747	0.641	0.176	-0.593	0.771	0.067	0.162	-1.916	-0.632	-0.167	–	0.450
Kunming	-0.162	-16.66	–	-28.8	1.345	-2.497	-0.809	1.447	-0.330	9.448	0.125	-0.939	0.607	0.362	0.529	0.958	-0.118	-0.095	-0.672	0.107
Lhasa	–	–	–	–	–	-0.671	–	–	–	–	–	1.028	1.009	-1.069	-0.563	1.498	–	–	-0.865	–
Xi'an	-0.570	-5.26	-1.988	-29.7	0.125	-0.398	-0.796	-0.715	-0.126	-4.597	3.763	0.245	-0.004	0.162	-0.702	-0.120	-0.424	-0.544	1.834	0.618
Lanzhou	-0.717	-25.76	–	-53.5	2.602	-0.551	-0.204	-0.124	-0.412	1.095	1.572	0.682	0.697	-0.629	-0.919	0.902	-0.414	-0.622	2.880	-2.209
Xining	-0.293	-37.10	-2.752	-59.1	0.595	-0.568	-1.023	0.372	-0.525	2.297	-3.158	0.924	-0.532	-1.621	-0.713	0.836	0.701	-0.465	0.123	-1.297
Yinchuan	-0.624	-37.21	0.002	-56.7	0.483	2.162	0.371	0.288	-0.572	0.003	-1.816	1.144	0.072	-0.808	-1.092	1.593	3.114	0.063	-1.050	-1.083
Urumqi	-0.017	-0.27	-0.535	-31.4	1.478	0.712	0.133	3.070	-0.431	1.202	-0.321	0.947	-3.023	-1.287	-0.986	0.908	0.137	-1.715	2.590	-0.768

of primary factors. The results are shown in Table 4.

2.4 Analysis of Correlation between Quality of Urban Living Environment and Primary Factors

The outcome of standard data processed is marked x_{ij} in Table 4, where i stands for the sample size, and j, the number of primary factors or variables. Hence the correlation coefficient (R) between the variables is mathematically expressed as:

$$R=(r_{ij})_{p \times p} \cdot n \qquad (3)$$

$$r_{ij}= \frac{\sum_{\alpha=1}^{n}(x_{\alpha i}-\bar{x}_i)(x_{\alpha j}-\bar{x}_j)}{\sqrt{\sum_{\alpha=1}^{n}(x_{\alpha i}-\bar{x}_i)^2} \cdot \sqrt{\sum_{\alpha=1}^{n}(x_{\alpha j}-\bar{x}_j)^2}}$$

$$=\frac{1}{n}\sum_{\alpha=1}^{n}x_{\alpha i} \cdot x_{\alpha j} \qquad (4)$$

where n represents the number of primary factors (variables), $x_{\alpha i}$ stands for the components in rows; $x_{\alpha j}$, those

in lines, and p, the number of rows and lines in Table 5. As indicated in the matrix, the numbers of rows and lines are equal.

As shown in Table 5, there are different levels of correlation between the quality of the urban living space and the evaluative factors, either positive or negative. The quality of the urban living space is most highly correlated with the economic situation x_1, which is understood to be of the strongest influence on the quality of urban life. In contrast, the quality of urban life is most loosely related to social security x_6, which evidently has the least effect on the quality of urban life.

In view of the correlation coefficients between the nine primary factors and the quality of urban life, positive and negative coefficients are offset in the process of calculation. As a result, it is concluded that economic situation (x_1), housing (x_2) and educational level (x_5) account for a cumulative ratio r ($r=\dfrac{x_1+x_2+x_5}{\sum\limits_{i=1}^{n}x_i}$, $n=9$) of

Table 4 Rank of the target Chinese provincial capitals in terms of composite index scores in 2001

City	Primary factor									Composite index (T_i)	Rank
	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9		
Shanghai	6.064	0.632	−0.055	0.347	11.846	−0.135	−0.149	−0.046	−0.030	3.500	1
Beijing	5.107	0.772	0.185	0.292	10.994	−0.087	0.005	0.060	0.006	3.185	2
Guangzhou	1.084	0.245	0.142	0.144	6.347	−0.086	0.430	0.158	−0.010	1.355	3
Tianjin	0.669	0.226	−0.051	0.040	4.999	0.047	−0.069	−0.043	−0.028	0.957	4
Fuzhou	−0.523	0.226	0.127	0.038	4.135	0.019	0.137	−0.016	0.019	0.548	5
Nanjing	0.014	0.012	−0.188	0.054	3.373	−0.030	0.017	0.097	0.026	0.498	6
Hefei	0.985	−0.083	0.147	0.129	1.116	−0.008	−0.014	0.022	0.085	0.444	7
Harbin	0.197	−0.100	0.674	−0.045	2.017	−0.158	−0.138	−0.041	−0.010	0.382	8
Hangzhou	−0.036	0.010	−0.127	−0.101	2.369	−0.040	0.107	0.018	0.001	0.337	9
Shijiazhuang	−0.473	0.011	0.135	0.023	1.674	0.033	−0.069	−0.040	0.016	0.135	10
Shenyang	−0.199	−0.147	−0.006	0.029	1.369	−0.168	−0.114	0.002	−0.034	0.103	11
Kunming	−0.494	−0.046	−0.127	0.018	1.435	−0.027	0.203	−0.009	−0.011	0.081	12
Zhengzhou	−0.515	−0.063	0.071	−0.044	1.535	−0.103	−0.052	−0.012	−0.004	0.072	13
Jinan	−0.495	0.051	−0.067	−0.004	1.186	−0.017	0.027	−0.024	−0.001	0.045	14
Wuhan	−0.051	−0.184	−0.151	−0.142	0.473	0.011	0.111	−0.027	−0.007	0.014	15
Chengdu	−0.053	0.213	−0.149	−0.088	0.262	−0.124	−0.132	−0.044	−0.030	0.010	16
Lhasa	–	–	−0.074	–	–	0.163	−0.015	–	−0.017	0.003	17
Urumqi	−0.036	−0.136	0.241	0.166	0.132	−0.166	−0.150	−0.063	0.036	−0.007	18
Changsha	−0.648	−0.041	−0.060	−0.078	1.159	0.010	0.086	−0.016	−0.001	−0.009	19
Changchun	0.259	−0.071	−0.242	−0.017	−0.871	0.191	0.031	−0.037	0.018	−0.082	20
Hohhot	−0.930	−0.136	0.007	−0.162	1.168	0.078	−0.100	−0.036	−0.180	−0.116	21
Haikou	−0.884	0.044	0.147	0.132	−0.025	0.179	0.396	0.134	0.021	−0.148	22
Xi'an	−0.296	−0.366	−0.030	0.098	−0.125	0.019	−0.073	−0.039	0.050	−0.154	23
Lanzhou	−0.889	−0.086	0.226	0.044	0.400	0.110	−0.071	−0.041	0.013	−0.164	24
Nanning	−0.827	0.090	0.073	−0.060	0.088	0.065	0.217	−0.008	0.033	−0.190	25
Taiyuan	−0.678	−0.103	0.136	−0.124	−0.249	0.049	−0.089	−0.021	−0.001	−0.236	26
Chongqing	0.502	−0.008	−0.318	−1.301	−1.646	−0.025	−0.104	−0.054	0.006	−0.241	27
Guiyang	−0.894	−0.025	−0.254	−0.118	0.122	0.009	−0.186	−0.032	0.009	−0.283	28
Nanchang	−0.884	−0.343	0.026	−0.006	−0.244	0.062	0.168	−0.036	−0.003	−0.309	29
Yinchuan	−1.173	−0.090	0.291	−0.029	−0.255	0.097	−0.034	0.127	−0.043	−0.331	30
Xining	−1.081	−0.535	0.003	−0.071	−0.129	0.031	−0.165	0.009	−0.023	−0.417	31

Note: Errors may occur in the results because data are statistically insufficient for the city of Lhasa

Table 5 Correlation analysis of the urban living environment and its primary factors

	T	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9
T	1.0000									
x_1	0.9725	1.0000								
x_2	0.8347	0.7934	1.0000							
x_3	0.1042	0.0443	−0.0327	1.0000						
x_4	0.4299	0.2981	0.2782	0.3704	1.0000					
x_5	0.9502	0.8621	0.8233	0.1356	0.4873	1.0000				
x_6	−0.4131	−0.4013	−0.4427	−0.1737	−0.0204	−0.4204	1.0000			
x_7	0.0151	−0.1010	0.0367	0.0124	0.1767	0.0670	0.2862	1.0000		
x_8	0.1578	0.1011	0.1801	0.1885	0.3562	0.2086	0.1322	0.5904	1.0000	
x_9	−0.0206	0.0046	0.0017	0.0466	0.0503	−0.0901	−0.0175	0.1879	0.0569	1.0000

90% in terms of their influence on the quality of urban life. That is, currently, they are the three dominant factors in determining the quality of urban life.

Of the nine primary factors, economic situation (x_1), educational level (x_5) and housing (x_2) are most related to the quality of urban living space (T), with their coefficients being greater than 0.9, 0.9, and 0.8 respectively. The coefficients between the economic situation (x_1) and the educational level(x_5), between housing (x_2) and the educational level(x_5), stay above 0.8. The coefficient between the economic situation(x_1) and housing(x_2) is over 0.7. The coefficient between climate conditions (x_7) and entertainment facilities(x_8) is greater than 0.5. The coefficient between transportation (x_4) and educational level (x_5) stands above 0.4. The coefficients between other factors are seen to be relatively low. On the basis of the analytical results, r, which is presumed to stand for the correlation between the quality of urban living (T) and the nine primary factors, may be used as a benchmark to divide the nine factors into three major categories: key factors $(r > 0.8)$, including the economic situation, educational level and housing; basic factors $(0.5 > r > 0.1)$, including transportation,   entertainment and health standard; and auxiliary factors $(r < 0.015)$, including climate, access to art and social security.

2.5 Rank of Chinese Provincial Cities

In accordance with the 2001 composite evaluation index, all the provincial capital cities of China may be ranked in descending order from A to E in terms of the living quality as presented in Fig. 2.

The 31 Chinese provincial cities may be ranked into five categories, A, B, C, D, and E in terms of living quality according to their composite index scores as presented in Table 6.

With a composite index score of more than 0.9, Shanghai, Beijing, Guangzhou, and Tianjin are ranked A, be-

cause they are more developed in science, economy, culture and education. They lead the whole country in the three key factors of economic situation, housing and educational level,   thus win the A status.   Taiyuan, Chongqing, Guiyang, Nanchang, Yinchuan and Xining are ranked E because their composite index scores are between −0.20 and −0.417. As a result, they are ranked low nationwide in terms of the living quality.

3 RESULTS

The preceding discussions of the living quality of the target Chinese cities may lead us to a few conclusions as follows:

(1) In accordance with the nine-factor theory set forth by the American urban geographer Rich BOYER in the 1980s, this study has made a comprehensive evaluation of the living quality in the target provincial capitals of China, chiefly because these cities are just equivalent to their American counterparts of the 1980s in terms of developmental levels, thus rendering our evaluation highly significant.

(2) In different social and historical periods, city dwellers place emphasis on different microscopic and macroscopic quality dimensions of urban living. In other words, demands on the urban living environment vary with the times.

(3) The fact that evaluating factors may largely vary with social and historical developments determines that all such factors are temporarily specified. Accordingly, the results of our evaluation and ranking of those provincial capitals are subject to social and historical changes.

(4) Certain errors may occur in the evaluation because the number of evaluating factors should have been greater and some original data were drawn at different times.
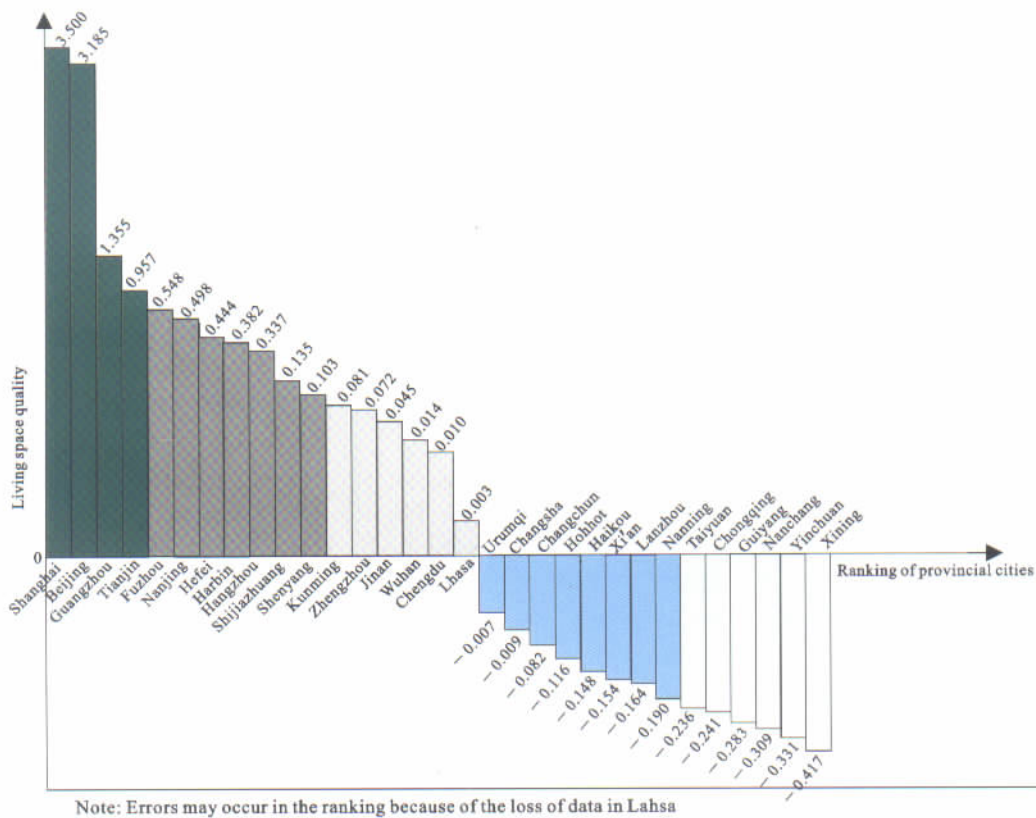
Fig. 2 Rank of Chinese provincial cities by the composite index score in 2001

Table 6   Categorization of Chinese provincial capitals by index scores in 2001

Rank	Composite index score	Cities
A	$T_i > 0.900$	Shanghai, Beijing, Guangzhou, Tianjin
B	$0.900 > T_i > 0.100$	Fuzhou, Nanjing, Hefei, Harbin, Hangzhou, Shijiazhuang, Shenyang
C	$0.100 > T_i > 0.003$	Kunming, Zhengzhou, Jinan, Wuhan, Chengdu, Lhasa
D	$0.003 > T_i > -0.200$	Urumqi, Changsha, Changchun, Hohhot, Haikou, Xi′an, Lanzhou, Nanning
E	$-0.200 > T_i > -0.417$	Taiyuan, Chongqing, Guiyang, Nanchang, Yinchuan, Xining

Note: Errors may occur in the ranking because of the loss of data in Lahsa

(5) Few cities such as Lhasa are not objectively ranked, because some original data are not available.

4 CONCLUSIONS

The key to an adequate evaluation of urban living environment is to establish an evaluation system, for urban living environment is affected by a complex, ever-changing array of factors. We have learned from this study article that establishing such a system is a difficult task, but what is even more difficult is to obtain original data in support of the primary factors. The evaluation results of the 31 Chinese provincial capitals are theoretically grounded, since our study is based on Rich BOYER′s nine-factor system. All analyses are relevant and com-prehensive in nature, and conform to the reality in China. Our research results show that there is a positive correlation between the quality of urban living and the size of a city. However, we can not generalize these findings to other contexts of a similar nature. In the long run, economic situation, educational level, housing and transportation will continue to be the dominant factors in the quality of urban life. However, there will be changing demands for the quality of the urban living space as a result of future social, economic, sci-tech, cultural and educational developments, combined with the improvement of the overall quality of urban residents. The data presented in Table 1 and the Chinese realities indicate that the focus of urban life in the past was on food, housing, education, transportation and en-

tertainment. But in the days to come, this focus will be shifted to such factor as information accessibility, green environment and air quality, as a result of knowledge-economic development.

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