Allocation of New Construction Land Based on Land Competitiveness Evaluation

HOU Guang-hui*, HUANG Ling-xiang

Department of Management Engineering, Tianjin Institute of Urban Construction, Tianjin 300384, China

Abstract Connotation of land competitiveness is expatiated from both the narrow sense and broad sense. Evaluation index system of land competitiveness is established according to the 2008 *China Statistical Yearbook and* 2008 *China Land Resources Statistical Yearbook*. Efficiency Coefficient Method and Principal Component Analysis Method are used to evaluate the land competitiveness of 31 provincial units in China. Result shows that in the year 2007, land competitiveness gradually decreases from southeast to northwest. The land competitiveness and GDP per unit land have significant negative correlation. The rank of approved new construction land has low positive correlation with the rank of land competitiveness in China. This indicates that there is little correlation between the allocation of regional new construction land and the land use efficiency. Therefore, it is suggested that regional allocation of new construction land should be treated differently based on the evaluation result of land competitiveness.

Key words Land competitiveness, New construction land, Pareto Optimality, Efficiency coefficient method, Principal component analysis, China

At present, arrangement of new construction land index adopts the two-level approval system of the State Council and provincial government. The State Council sets quotas of newly-increased construction land according to the land use planning and the application of each province. Then, each province allocates the index of new construction land to cities and regions with the approval of provincial government. According to the layer of central government and provincial government, arrangement of construction land is undoubtedly an important starting point of the coordinated development of regional economy. It is well known that affected by the guiding role of GDP, local governments have the motive of blind expansion of construction land. On the one hand, they vigorously implement industrial expansion and increase GDP and fiscal revenue. On the other hand, local governments rely on selling land to support government expenditure. Therefore, index requirement of construction land is usually more than the actual needs of social and economic development. Under this situation, it is necessary to establish a mechanism to investigate the index utilization of new construction land, which can be used as the basis for the follow-up arrangements of land index and has important theoretical and practical value.

Based on the above analysis, concept of land competitiveness is put forward for the first time, trying to apply the evaluation result of land competitiveness in the allocation of construction land index, and providing reference for the improvement of land use planning in China.

1 Connotation of land competitiveness

Land competitiveness comes from the comparative efficiency of land input-output ratio and land use. The generalized connotation of land competitiveness includes three layers. As for the investor, land competitiveness includes the sound investment environment, available surrounding facilities, high industry agglomeration and good return of investment. As for the effect of land use, land competitiveness refers to the high comprehensive benefit of land use, such as economic, social and ecological benefits. As for the allocation of regional land use index, areas with high land competitiveness can create more social wealth. Thus, land use index should be allocated according to the level of land competitiveness, which is conducive to exert the advantages of advanced regions and to improve the overall efficiency.

In the narrow sense, land competitiveness refers to the reality and potential of a certain region to create social wealth by using land resources. It is an objective basis for central government and provincial government to allocate land use index.

2 Data source, research method and index system construction

2.1 Data source Research data are from the 2008 *China Statistical Yearbook*, and the statistics of provincial units in the year 2007. New construction land of provincial units approved by the State Council and provincial government in the year 2007 is from the 2008 *China Land Resources Statistical Yearbook*.

2.2 Research method To improve the scientificity of land competitiveness evaluation, both Efficiency Coefficient Method and Principal Component Analysis Method are used. Then, comprehensive weighted assessment is carried out. Both of the two methods calculate the comprehensive evaluation score, determine the index weight and carry out standardization of data. Finally, comprehensive evaluation score is used to reflect the relative differences among evaluation objects[1].

2.2.1 Efficiency Coefficient Method.

(1) Standardization of data. There are both positive index and negative index in the evaluation indices. Hence, the corre-

Received: September 15, 2010 Accepted: November 25, 2010
Supported by the Natural Science Foundation of China (70803032).
* Corresponding author. E-mail: Skycloudy04@126.com

sponding two equations are selected to transform the positive index and negative index:

$$d_{ij} = 40 \times \frac{x_{ij} - x_j^s}{x_j^h - x_j^s} + 60 \quad (1)$$

$$d_{ij} = 40 \times \frac{x_j^h - x_{ij}}{x_j^h - x_j^s} + 60 \quad (2)$$

Equation (1) and (2) are the standardization equations of positive index and negative index, respectively. $i = 1,2,\cdots\cdots,p; j = 1,2,\cdots\cdots,m$; x_{ij} is the raw value of the jth index in the ith evaluation unit; d_{ij} is the efficiency fraction of the jth index in the ith evaluation unit; p is the number of evaluation units; m is the number of indices; x_j^s is the non-permitting value of the jth index and the minimum value of this index statistic is adopted; x_j^h is the satisfied value of the jth index and the maximum value of this index statistic is adopted.

(2) Determination of weight. Weight is determined by variation coefficient method. It is assumed that $\bar{x}_j$ is the mean value of jth index in different evaluation units, s_j is the standard deviation of the jth index in different evaluation units, that is $s_j = \sqrt{\frac{1}{p-1}\sum_{i=1}^{p}(x_{ij} - \bar{x}_j)^2}$. Hence, the variation coefficient of standard deviation of the jth index is $v_j = s_j / |\bar{x}_j|$. The weight of the jth index is:

$$w_j = v_j / \sum_{j=1}^{m} v_j \quad (3)$$

In this research, if a certain index has relatively great variation coefficient of standard deviation, it means that there is great variation among different evaluation objects. Thus, this index has strong distinguishing capability, which should be paid attention to.

(3) Calculation of the score of efficiency coefficient. Efficiency fractions are synthesized by geometrical weighted average, so as to obtain the total efficiency fraction. Higher value indicates better comprehensive benefit and *vice versa*. Total efficiency fraction can be used to compare the evaluation units.

$$y_j = \prod_{i=1}^{p} d_{ij}^{w_j} \quad (4)$$

2.2.2 Principal Component Analysis Method. Principal Component Analysis Method is put forward by Hotelling. This method has several advantages: weight determined is based on data analysis and reflects the internal structure relationship among indices. Therefore, it is not affected by subjective factors and the comprehensive indices obtained are independent with less cross of information. Therefore, the analysis result has the characteristics of objectivity and determinability[2].

The core of this method is to select n principle components (Y_1, Y_2, $\cdots$, Y_n) through the principal component analysis. Y_i ($i = 1,2,\cdots,n$) is the score of the ith principal component. Taking variance contribution a_i of principal component Y_i as the weight, comprehensive evaluative function is established: $Y = a_1 Y_1 + a_2 Y_2 + \cdots + a_n Y_n$. After calculating the principal components of all the evaluation units, we can obtain the comprehensive score and sequence is lined up according to the scores.

2.3 Establishment of evaluation index system Evaluation of land competitiveness is the basic work of land use allocation. According to the scientific, operable, dynamic and forward-looking principles, economic, social and environmental benefits of land use are taken into account based on the research results of Zhan Meixu, Wang Liping and Yin Shaomei[3-5]. Table 1 reports the index system of land competitiveness evaluation in China. According to the table, there are 3 second-grade indices, 9 third-grade indices and 27 fourth-grade indices. Except the three indices describing environmental quality (industrial wastewater discharge amount per unit land, wastewater discharge amount per unit land, and domestic garbage discharge amount per unit land), the rest are all positive indices. The greater value indicates stronger land competitiveness.

Table 1 Index system of land competitiveness evaluation in China

Evaluation objective	Evaluation criteria	Evaluation factor	Evaluation index
Land competitiveness	Economic benefit	Investment intensity	Fixed assets investment per unit land
			Fiscal expenditure per unit land
			Gross investment per unit land of foreign-invested enterprises
			Volume of business in technical market per unit land
		Output benefit	GDP per unit land
			Financial revenue per unit land
			Gross social retail sales per unit land
			Industrial enterprises above designated size per unit land
		Output structure	Added value of secondary industry per unit land
			Added value of tertiary industry per unit land
		Expansion benefit	Economic elasticity index of urban land expansion
	Social benefit	Social agglomeration degree	Non-agricultural employees per unit land
			Proportion of employees in tertiary industry
			Urbanization level of population
		Infrastructure supply level	Per capita urban road
			Number of people with a bus in every then thousand people
			Urban water consumption rate
			Urban gas consumption rate
		Standard of living	Per capita disposable income of urban residents
			Per capita housing area

Continued (Table 1)

Evaluation objective	Evaluation criteria	Evaluation factor	Evaluation index
	Environmental benefit	Environmental quality	Industrial wastewater discharge amount per unit land
			Wastewater discharge amount per unit land
			Domestic garbage discharge amount per unit land
		Environmental control level	Public green area per capita
			Coverage rate of built-up green area
			Output value of products utilizing three wastes per unit land
			Treatment ratio of domestic garbage

Note: Economic elasticity index of urban land expansion = Annual average growth rate of the secondary and tertiary industries in the built-up region during the latest three years / Annual average growth rate of the built-up area.

3 Empirical research on the comparison of land competitiveness

3.1 Evaluation by Efficiency Coefficient Method According to the methods mentioned above for calculating the efficiency coefficient, the positive or negative attribute of indices in Table 1 are determined. After selecting the corresponding standardization equation, weight of index is determined by using the method of standard deviation coefficient. Finally, scores of efficiency coefficients for provincial units are calculated, result of which is listed in the column of " score of efficiency coefficient" in Table 2.

3.2 Evaluation by Principal Component Analysis Method

3.2.1 Standardization of the raw data. Standardization data can eliminate the variation tendency of indices, the dimensional inconsistencies, and the differences in magnitude. Correlation matrix R of variables is established. And collinearity diagnosis of R is carried out by using SPSS software, so as to obtain certain correlation among variables.

3.2.2 Calculation of the eigenvalue, contribution rate, and cumulative contribution rate of R. The eigenvalues of the first 5 components are greater than 1 and their cumulative contribution rate reaches 76.243%. In other words, the information of the 5 components accounts for 76.243% of the overall information of raw variables (Table 3).

Table 3 Main eigenvalues and contribution rates of principal component analysis

Principal component	Eigenvalue	Contribution rate//%	Cumulative contribution rate//%
F_1	9.547	35.358	35.358
F_2	4.454	16.498	51.856
F_3	2.938	10.881	62.737
F_4	2.203	8.159	70.897
F_5	1.444	5.347	76.243

3.2.3 Establishment of evaluation model by integrating principal components. Based on the analysis of the principal components, 5 principal components are selected to establish the comprehensive evaluation function by taking their variance contribution rate as the weight:

$$Z=0.353\,58F_1+0.164\,98F_2+0.108\,81F_3+0.081\,59F_4+0.053\,47F_5 \quad (5)$$

Principal components of evaluation units are obtained automatically by SPSS. According to the equation (5), comprehensive score of principal component of each province in China can be obtained, which is denoted by $Z_i(i=1,2,\cdots,31)$. Table 2 reports the rank of provinces in China.

Table 2 Evaluation result of land competitiveness in each region and the index of approved construction land in 2007 hm^2

Rank of land competitiveness	Region	Score of efficiency coefficient	Score of principal component	Comprehensive score	Approved construction land
1	Zhejiang	83.64	0.93	90.18	28 271.90(3)
2	Jiangsu	82.17	0.84	88.48	19 892.33(6)
3	Shanghai	85.55	0.6	88.29	6 082.56(25)
4	Fujian	80.48	0.63	85.49	18 526.00(9)
5	Shandong	79.39	0.6	84.61	28 297.99(2)
6	Tianjin	80.74	0.4	83.55	10 306.45(18)
7	Beijing	82.17	0.25	83.06	6 810.27(22)
8	Hebei	76.13	0.25	79.44	11 130.98(17)
9	Chongqing	75.84	0.08	77.71	14 165.86(15)
10	Yunnan	75.80	0.04	77.32	25 431.92(4)
11	Jiangxi	75.19	0.08	77.32	12 449.23(16)
12	Shaanxi	75.61	0	76.8	6 088.37(24)
13	Qinghai	76.16	−0.07	76.54	4 723.87(28)
14	Hubei	74.18	0.04	76.35	14 412.56(14)
15	Hunan	74.73	0	76.29	28 454.83(1)
16	Sichuan	74.42	0.01	76.23	17 906.61(11)
17	Guangdong	74.43	−0.06	75.56	17 306.43(12)
18	Liaoning	74.73	−0.12	75.18	17 910.76(10)
19	Anhui	72.84	−0.05	74.74	18 802.22(8)
20	Henan	73.05	−0.06	74.74	18 818.95(7)

Continued (Table 2)

Rank of land competitiveness	Region	Score of efficiency coefficient	Score of principal component	Comprehensive score	Approved construction land
21	Guangxi	72.65	−0.05	74.62	20 761.78(5)
22	Inner Mongolia	72.91	−0.12	74.09	16 790.25(13)
23	Shanxi	72.86	−0.25	72.93	7 241.48(21)
24	Tibet	72.12	−0.34	71.61	2 981.71(29)
25	Hainan	71.9	−0.37	71.2	2 920.50(30)
26	Xinjiang	70.77	−0.34	70.84	8 718.69(19)
27	Ningxia	69.54	−0.32	70.28	5 402.64(27)
28	Guizhou	71.6	−0.52	69.64	6 495.14(23)
29	Jilin	70.29	−0.48	69.21	7 671.69(20)
30	Gansu	67.85	−0.68	65.91	2 367.27(31)
31	Heilongjiang	67.44	−0.81	64.47	5 648.78(26)

Note: The state approved construction land includes the construction land approved by the state council and provincial government; the data in the brackets refer to the rank of the construction land area approved by the State Council.

3.2.4 Comprehensive treatment on evaluation result. The two methods have different score magnitudes of land competitiveness. Therefore, their results can not be directly combined together. Scores of principal components are treated and are converted into 60 – 100 score value according to equation (1). After conversion, the ranks obtained by two methods are found to be in good agreement. However, the cumulative contribution rate of 5 principal components is less than 80% in the comprehensive evaluation model of principal component analysis, that is, there is certain error when the original evaluation indices are replaced by the 5 principal components during evaluation. Thus, it is assumed that the comprehensive score weight of principal component is 0.4; while score weight of efficiency coefficient method is 0.6. After weighted calculation, the rank of scores is listed in the column of "comprehensive score" in Table 2.

3.3 Analysis of competitiveness result

3.3.1 Geographical distribution of land competitiveness and its main influencing factors. According to the geographical distribution, land competitiveness gradually decreases from southeast to northwest. The top-five provinces all belong to the east region of china, including Zhejiang, Jiangsu, Shanghai, Fuzhou and Shandong. And the five provinces at the bottom of the list, such as Ningxia, Guizhou, Jilin, Gansu and Heilongjiang, are located in western and northern China. Provinces at the middle of the list are mostly located in central China. According to the relationship between land competitiveness and GDP index per unit land, the rank of land competitiveness falls with the decrease of GDP index per unit land. The two show significant negative correlation and their Pearson correlation coefficient is −0.802, reflecting that land competitiveness is greatly affected by the economic factor. Economic effect of land use is the main aspect for the evaluation of land competitiveness.

3.3.2 Correlation analysis between the land competitiveness and the approved new construction land. Spearman rank correlation analysis between the rank of land competitiveness and the rank of approved new construction land is carried out in 31 provincial units in China. Result shows that there is significant correlation between the rank of land competitiveness and the rank of approved land at 0.01 level; but the correlation coefficient is only 0.471. Pearson correlation analysis between land competitiveness score and approved construction land area shows that they have significant correlation at 0.01 level, but the correlation coefficient is only 0.487. This shows that the allocation of new construction land in China has low positive correlation with the land competitiveness, that is, it has little correlation with the land use efficiency. The reason is that the allocation of construction land is determined by the governments and public game, according to the demand of economic development for construction land in different areas. However, considering the local development and government performance, many areas want to have larger area of construction land[6]. Thus, the situation of "getting more approved land if asking for more" has formed.

3.3.3 Allocation of new construction land. Index allocation of new construction land mainly relies on the circulation of rural land. Maintaining a certain amount of arable land is crucial to the grain security and the stable development of society and economy. Thus, index allocation should be very careful. It is believed that regional allocation of new construction land should be treated differently based on the evaluation result of land competitiveness. In other words, planners of land supply should allocate more land to the areas with stronger land competitiveness and better comprehensive effect of land use, as well as the areas where land becomes a restriction factor of social and economic development.

As for the top-five provinces and cities, such as Zhejiang, Jiangsu, Shanghai, Fujian and Shandong, central government should try to meet their reasonable land demands in major projects during socio-economic development. Based on the project demonstration, the use of cultivated land is permitted to a certain extent. As for the ten provinces at the bottom of the list, such as Inner Mongolia, Shanxi, Tibet, Hainan, Xinjiang, Ningxia, Guizhou, Jilin, Gansu, and Heilongjiang, index of new construction land should be temporarily suspended; polices should be made to promote the use of construction land in stock and to improve the land input-output ratio. As for the 16 provinces at the middle of land competitiveness list, such as Tianjin, Beijing, Hebei, Chongqing, Yunnan, Jiangxi, Shaanxi, Qinghai, Hubei, Hunan, Sichuan, Guangdong, Liaoning, Anhui, Henan and Guangxi, necessary index of new construction land should be supplied and the growth rate of construction land should be rationally controlled. At the same time, land input should be increased and intensive level should be improved.

4 Conclusion

Land competitiveness is a concept that develops continuously, a concentrated expression of pursuing the greatest social achievements of land use. It reflects the integration of social, economic and ecological benefits. Land competitiveness, showing the values and goals of land users, has different characteristics at different stages of social development. Within a specific period in China, economic benefit of land use is the core of land competitiveness. Land competitiveness offers a new evaluation means for the effectiveness of land use, affects the allocation of overall land use planning as a policy tool, and puts forward a new idea for the index allocation of new construction land in China in the new period of time.

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