Space Syntax Method Based Study on Price Adjustment of Land Location: A Case Study of the Development of GY Island

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Received 15 November 2014, www.cmnt.lv

Abstract

Based on theoretical analysis of Space syntax and other associated concepts, the essay developed an innovative method of land location price adjustment. We take GY Island (in the Yangtze River) as research object. With the help of space syntax and Mindwalk software, we conducted detailed analysis on each land block, and finally give rate depending on locations. The results show the convenience and accuracy of adopting space syntax in calculating the land price by the location adjustment coefficient.

Keywords: Space syntax; Land appraisal; Price adjustment on locations

1 Introduction

Rational land appraisal lays the foundation for ensuring the effectiveness of urban land market and the healthy development of real estate [1]. After determining the standard land price, there is also need to appraise the market price of different land blocks effectively, by price adjustment coefficients such as location, volume rate and time, etc. [2]. What's more, location is considered one of the most important in various affecting factors of the land price. So the determination of location price adjustment coefficient turns out to be crucial [3]. Johann Heinrich von Thünen, German economist, put forward location theory for the first time. It was applied into the early agricultural land appraisal. After the research of Christaller. Walter, this theory is promoted to the city residence and industrial land evaluation [4].There are also a lot of land location factor appraisal research in China. Shi Jiangang analyses the locational factors of real estate and put forward the principle of location selection of real estate development qualitatively [5]; Zhou Luhong think that the location factor is most important in determining urban land price with the example of the analysis of location and urban land price in Nanjing [6]. Therefore, land location value is mostly valued by subjective ratings and lack the lack objective quantitative tools for support [7]. As a new kind of computer language, space syntax described the modern urban spatial patterns [8-9]. It's mean to use the traffic path to scale space partition and analysis the complex topology, geometry, and actual distance. It's not only focus on local spatial accessibility, and also emphasizes the whole space. What's more, location of urban land value evaluation is also a kind of factors based on spatial relationship of land. Several kinds of commonly used variable form for space syntax have relationship with the location of the value [10-11]. So, this paper tries to use space syntax to determine the location value of urban land quantitatively and further to determine reasonable land transfer price.

2 The principle of space syntax

Space syntax, as a new language for description of architecture and city space pattern, recognizes the space as part of social and economic activities. It is often used in architecture and city of different scales, ranging from individual building to city district, whole city, and even the whole regional etc. The basic principle of space syntax is spatial segmentation. The commonly used way is the line method, which is to simplify all paths in an area into lines, and covering the entire region by longest and fewest lines. Each line is regarded as a node, and the whole map is called axis diagram. After Adjusting and calculating the inputted axis diagram, we get several commonly used morphological variable values as follow:

(1) Connection value: the number of neighboring nodes a node has connected is its connection value. A space with higher connection value has better space permeability, and so its commercial value is higher.
(2) Control value: we assume the weight of each node in the system is 1, then the weight assigned to node A from neighboring node B is 1/(connection value of node B) if there is only one node B connected to node A. So theoretically, the control value of node A refers to the weight a node is assigned by its neighboring nodes, which in calculation, is the reciprocal sum of connection value of all neighboring nodes. Control value represents the degree of control between each other nodes. Space influence would increase with the control value. So the commercial value has positive correlation to the control value.
(3) Depth value: in provision that the distance between two neighboring node is one step, and then the minimum step from one node to the other is call depth value. In the system, the average depth value of a node to all the other nodes MD= ($\sum$ depth×the number of node in this depth) / (the total number of nodes -1). It expresses the topological accessibility of a node, which in another word, the level of convenience of a node in space. The

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smaller the depth value, the more convenient the location is.

(4) Integration: integration is to eliminate the interference of system elements in process of calculating the depth value. It is measured by relative asymmetry (RA), which standardizes the depth value. The equation is RA=2× (MD-1)/ (number of node -2). The reciprocal of RA is called integration. The equation can be further standardized, using RRA to add comparability between spaces of different size. $RRA=RA/D_n$, $D_n=2\{n\times[\log_2((n+2)/3)-1]+1\}/[(n-1)\times(n-2)]$. There are two types of integration: overall integration and partial integration. The overall integration represents the closeness between a node and all the rest nodes in system. The closer the connection is, the higher the commercial value is. Partial integration illustrates the closeness between a node and its neighboring nodes. The confidentiality drops with the growth of partial integration.

3 Case study

In this essay, we take example of an island development project in Chongqing. With the help of space syntax, we can determine the adjustment coefficient of different locations and finally the land value. Through combination of cost approach, market comparison approach, residual method and present earning value method, the standard price for residential purpose land is 4.45 million RMB / acre; and the price for commercial purpose land is 9.3 million RMB/ acre.

3.1 ESTABLISHING THE CRITERIA FOR PRICING LAND LOCATION.

Based on massive investigation on field project and interviews on experts of various domains and technicians, a brief land location price appraisal system has been established. For the residential land, the criteria include: landscape resource, confidentiality, Land plasticity, public service level and the convenience of transportation. While for commercial land, there are only three criteria which are connection value, control value and overall integration. In order to minimize the influence of subjective factors in land appraisal, we adopt space syntax to adjust some criteria. Among them, the confidentiality of residential land is represented by partial integration. Partial integration illustrates the closeness between a node and its neighboring nodes. The confidentiality drops with the increase of partial integration. Normally, the scope of calculation of integration ranges from three to ten steps, which called "radius of-3 integration" or "radius of-10 integration". Here we use "radius of-3 integration". The convenience of transportation can be expressed by depth value in space syntax. In space syntax, we set the distance between two neighboring node as one step, and then the minimum step from one node to the other is call depth value. Since the depth value represents accessibility in topology sense, it can be used in describing the ease of access of land.

In commercial land appraisal, the connection value refers to the number of neighboring nodes a node is connected. In actual space system, space with higher connection value enjoys better space permeability and so its commercial value is higher. Control value represents the degree of control between nodes. Land with higher control value has higher influence and commercial value. The overall integration represents the closeness between a node and all the rest nodes within system. The closer the connection is, the higher the commercial value is.

3.2 DETERMINING THE WEIGHT OF EACH CRITERION

Considering the need to satisfy high-end market after project completion, we integrate the characteristics of high-end residential properties with targeted customer requirement to determine the weight of five criteria demonstrated in TABLE 1.

TABLE 1. Weight of criteria for residential purpose land

Index	Weight
Landscape resources	0.40
Privacy	0.20
Plasticity of land	0.15
Perfect degree of public service	0.10
Transportation convenience	0.15

Combining the demand of commercial configuration and the rule of space syntax, the three weights of criteria for commercial land is demonstrated in TABLE 2.

TABLE 2. Weight of criteria for commercial purpose land

Index	Weight
linking number	1/3
control value	1/3
the whole integration level	1/3

3.3 ANALYSIS THE CHARACTERISTIC OF EACH BLOCK

Before giving the evaluation to each criterion, it is necessary to have clear prospects on characteristic of each land block in order to make it more accurate. Due to the large amount of blocks in island, we only select some of them in TABLE 3.

TABLE 3. Characteristic of land blocks

Land number	Land category	Green space ratio	Traffic condition	Landscape resources	Public Service Facilities	Privacy	Plasticity of land
W1-2/02	C	25	Circled by landscape road	Circled by ecological park and have beautiful scenery	post office, switching station, toilet	——	It's a High prone to geological disasters in eastside
W1-4/02	C	25	Circled by landscape road in the south	Circled by ecological park	——	——	Block founder

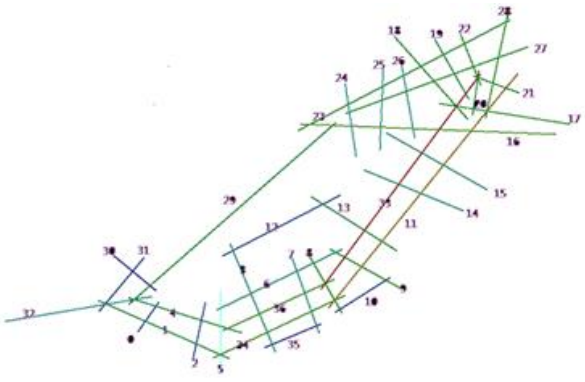
Land number	Land category	Green space ratio	Traffic condition	Landscape resources	Public Service Facilities	Privacy	Plasticity of land
				and have beautiful scenery			
W1-6/02	C	25	Next to the landscape in the north	Circled by ecological park and have beautiful scenery	——	——	Block founder
W2-2/02	R	40	Circled by landscape road in the southwest and west	Near the coast and there are public tree lawn in the northwest	——	The noise is small and privacy is good	Block founder and gently topography
W2-3/02	R	40	Next to the main road in the north and landscape in the southwest	Near the coast and there are ecological park in the south	CBD, toilet	Next to the main road and noise and privacy is worse	Block founder and gently topography
W2-5/02	R	40	Circled by road	Near the coast and there are ecological park in south	Kindergarten, switching station	noise and privacy is worse	Block founder and gently topography

3.4 SCORE OF EACH CRITERION OF EACH LAND BLOCK

For the residential land, we use partial integration and depth value to represent confidentiality and the convenience of transportation respectively. While criteria such as landscape resources, land plasticity and convenience of transportation still require subjective rating. For commercial land, there are only three criteria which are connection value, control value and overall integration. The data of commercial land can be calculated by Mindwalk software.

3.4.1 Setting up axis diagram

With the help of AutoCAD, we built the axis diagram of the island in reflecting the real road network. The diagram contains a group of longest and fewest lines (in FIGURE 1).



FIRURE 1. Axis diagram of the island

3.4.2 Calculation of morphological variables of each route

Input the axis diagram into Mindwalk software and get the morphological variable value of each route in space syntax system demonstrated in TABLE 4.

TABLE 4. Value of morphological variables of each route

Serial number	linking number	control value	depth value	the partial integration level	the global integration level
0	2	0.3333	3	1.4028	1.2459
1	6	2.0000	3	1.9416	1.6544
2	2	0.3333	3	1.4028	1.2459
3	5	1.5667	2	1.8840	1.7104
4	6	1.9500	2	2.0186	1.9407
5	4	0.7000	3	1.8861	1.6277
6	5	1.1167	2	1.8840	1.7104
7	4	1.0667	2	1.7555	1.6277
8	6	1.2436	1	2.3626	2.2936
9	4	0.8769	1	2.1914	1.9407
10	2	0.4167	2	1.3992	1.3106
11	10	2.6595	2	2.9681	2.9681
12	2	0.5333	2	1.4539	1.3456
13	3	0.6769	1	1.9776	1.8021
14	2	0.1769	1	1.8391	1.6819
15	2	0.1769	1	1.8391	1.6819
16	7	1.5519	1	2.5491	2.4614
17	5	0.8769	1	2.0876	1.8348
18	4	0.5448	1	2.1784	1.7705
19	3	0.3448	1	2.0502	1.7104
20	4	0.6769	1	1.9917	1.6819
21	5	0.8269	1	2.0876	1.8348
22	5	0.7948	1	2.2486	1.8021
23	8	2.1262	2	2.1771	1.6554
24	3	0.4107	2	1.6795	1.4626
25	3	0.4107	2	1.6795	1.4626
26	3	0.4107	2	1.6795	1.4626
27	7	1.9833	2	2.1024	1.4626
28	5	0.7679	2	2.2258	1.8688
29	4	1.0595	2	1.9324	1.8348
30	2	0.5835	3	1.2410	1.1738
31	3	0.9167	4	1.4635	1.1877
32	4	0.9167	3	1.6667	1.4016
33	13	3.5262	0	3.3402	3.1536
34	6	1.1333	2	2.4614	2.4614
35	2	0.4500	3	1.1769	1.0969
36	5	0.8603	1	2.5229	2.5229

3.4.3 Quantitative calculation of each land block's

criterion

The connection value, control value and overall integration of each land block are calculated by adding the morphological variables of its' neighboring route together. Take commercial purpose land W1-2/02 as example, we get the planning map (in FIGURE 2).

FIGURE 2. Planning map of block W1-2/02

The reference of surrounding route is numbered as 29, 30, 31 and 32 respectively. Connection value of the four routes are 4, 2, 3, and 4. The control value of each route is 1.0595, 0.5833, 0.9167and 0.9167, and the overall integration of each repute is 1.8348, 1.1734, 1.1873 and 1.4016. So the connection value of block W1-2/02 is 13(4+2+3+4), control value is 3.4764(1.0595+ 0.5835+0.9167+0.9167), and the overall integration is 5.5979(1.8348+1.1738+1.1877+1.4016).

The depth value of each residential land is measured according to the average depth value of its neighboring routes. Similarly, partial integration is also the sum of partial integration of neighboring routes. Take residential purpose land W2-2/02 as example, we get the planning map (in FIGURE 3).

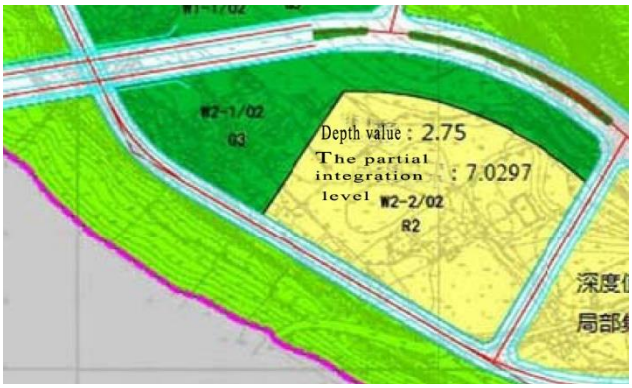


FIGURE 3. Planning map of block W2-2/02

The reference of surrounding route is numbered as 0, 1, 4 and 32 respectively. The depth value of the four routes are 3, 3, 2 and 3. The partial integration of each route are 1.4028, 1.9416, 2.0186 and 1.6667. So the depth value of block W1-2/02 is (3+3+2+3)/4=2.75, the partial integration 1.4028+1.9416+2.0186+1.6667=7.0297.

Following the same method of calculation, TABLE 5 illustrates the score of quantitative criteria of each land block.

TABLE 5. Quantitative criteria of selected land block depth value

Land number	Land category	linking number	control value	the global integration level	the partial integration level(privacy)	depth value (Transportation convenience)
W1-2/02	C	13	3.4764	5.5979	-	-
W1-4/02	C	4	1.0595	1.8348	-	-
W1-6/02	C	4	1.0595	1.8348	-	-
W2-2/02	R	-	-	-	7.0297	2.7500
W2-3/02	R	-	-	-	6.7658	2.7500
W2-5/02	R	-	-	-	7.2491	2.7500

3.4.4 Establishing marking standard of each criterion

We use hundred-mark system in marking each criterion of each land block. The results are shown from TABLE 6 to TABLE 11.

TABLE 6. Marking standard for confidentiality (partial integration)

the partial integration level	score
>10	75
2-10	100-75
<2	100

TABLE 7. Marking standard for convenience of transportation (depth value)

depth value	score
0-5	100-75

TABLE 8. Marking standaard for landscape resource, land plasticity and public service level

	VG	Good	M	Poor	VP
Landscape resources	100-96	95-91	90-86	85-81	80-75
Plasticity of land	100-96	95-91	90-86	85-81	80-75
Perfect degree of public service	100-96	95-91	90-86	85-81	80-75

Notes:VG=Very good,M= Moderate,VP=Very Poor

TABLE 9. Marking standard for connection value

Link number	score
0-30	75-100

TABLE 10. Marking standard for control value

Control value	score
0-8	75-100

TABLE 11. Marking standard for overall integration

the global integration level	score
0-10	75-100

3.4.5 Rating for each land block

After determining the marking standard, we adopt space syntax to calculate the confidentiality, convenience of transportation, connection value, control value and overall integration, and come up with the scores using linear interpolation method. As to the landscape resource, Land plasticity and public service level, we ask experts to give rate based on their professional interpretation on these criteria. By using the equation $S_i=\sum_{j=1}^{n} w_j F_{ij}$, we are able to evaluate the land block comprehensively. S_i represents an overall score of land block i, n refers to evaluation index. Residential land n=5, commercial land n=3; W_j is the weight of criteria j, F_{ij} is the score of criteria j in land block i. the final result of residential land and commercial land is shown in TABLE 12 and 13 respectively.

TABLE 12. Rating result for residential purpose land

Land number	Land category	Landscape resources (0.4)	Privacy (0.2)	Plasticity (0.15)	Perfect degree of public service (0.1)	Transportation convenience (0.15)	Average score
W2-2/02	R	93	84	99	75	86	89
W2-3/02	R	95	85	97	93	86	92
W2-5/02	R	92	84	98	92	86	90

TABLE 13. Rating result for commercial purpose land

Land number	Land category	Link number(1/3)	Control value(1/3)	The global integration level(1/3)	Average score
W1-2/02	C	86	86	89	87
W1-4/02	C	78	78	80	79
W1-6/02	C	78	78	80	79

3.5 CALCULATE LOCATION PRICE COEFFICIENT

According to the method we demonstrate above, the average score of residential purpose land is 90, and that of commercial purpose land is 88. The average score of each land block divided by the total average score, we gain the location price adjustment coefficient in TABLE 14.

TABLE 14. Location price coefficient of each land block

Land number	Land category	Location adjustment coefficient
W1-2/02	C	0.99
W1-4/02	C	0.90
W1-6/02	C	0.90
W2-2/02	R	0.99
W2-3/02	R	1.02
W2-5/02	R	1.00

3.6 CALCULATION OF THE FINAL LAND PRICE

The finally land price is calculated by the equation below: The final land price= standard price × location adjustment coefficient × Volume rate adjustment coefficient × time adjustment coefficient.

The essay will not spend time explaining the way of calculating Volume rate adjustment coefficient and time adjustment coefficient since they are quite easy, and there are plenty of explanations in previous studies. The final land price is shown in TABLE 15.

TABLE 15. Price of each land block in GY Island

Development block	Land number	Location adjustment coefficient	Floor area ratio coefficient	Time adjustment coefficient	Reference granting price (million yuan/mu)	The final price (million yuan/mu)
W1	W1-2/02	0.99	1.00	1.03	9.30	9.48
	W1-4/02	0.90	1.00	1.03	9.30	8.62
	W1-6/02	0.90	1.00	1.03	9.30	8.62
W2	W2-2/02	0.99	1.00	1.00	4.45	4.41
	W2-3/02	1.02	1.00	1.00	4.45	4.54
	W2-5/02	1.00	1.00	1.00	4.45	4.45

Notes:1 hectare=15 mu

4 Conclusions

Through the case study, we can come to the conclusion that the space syntax is much easier to implement and perform well in evaluation of different blocks in massive land development. In the calculation, we first evaluate price adjustment coefficient and value of location by space syntax, before finally estimating the land cost. Compared with the

traditional methods, space syntax improves the stability and accuracy of land appraisal. Although through the use of space syntax, the majority of criteria are evaluated objectively, there are some quantitative criteria remains under subjective scoring. The future research perspective should focus on improvement of this method to make it more objective and scientific.

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Acknowledgements

The authors would like to thank the Sustainable Construction Research Programme of Chongqing University.

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