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AN ANALYSIS ON LOCATION FACTORS AFFECTING THE SPATIAL DISTRIBUTION OF SHANGHAI LAND VALUES

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ABSTRACT: With a technique of GIS(Geographical Information System) and a method of multiple linear regression analysis, the spatial distribution of Shanghai land values and its relationship with some location factors are examined in this paper. The database of land values consists of 166 land parcels leased during 1993-1994. The land value map shows that the spatial distribution of Shanghai land values has some distinct spatial features. Firstly, the highest land value areas are located along Nanjing Road, Huaihai Road and the Bund. Secondly, there is no conspicuous peak land value intersection within the CBD(Central Business District). Finally, The land values of Pudong are much lower than those of Puxi. The regression model between Shanghai land values and the selected location factors shows that Nanjing Road is the first important location factor affecting the spatial distribution of the land values, the city center is the second one and Huaihai Road is the third one. The Bund, the regional shopping centers and the transportation nodes have little influence on the land values. This relationship between Shanghai land values and the location factors is determined by the distribution of commercial activities, the characteristics of the CBD and the spatial form of the city.
KEY WORDS: Shanghai, land values, location factors, multiple regression analysis, GIS

I. INTRODUCTION

There is a close correlation between the location of a land parcel and its value. A real estate expert once stated that the factors determining a "good" piece of land are its location, its location, and its location (Northam, 1978). So the urban land values become an important subfield of urban geography. Urban land values can be considered in two contexts. One is the market land value, which is the price of a land parcel negotiated at the time of sale of the parcel. The other is the assessed land values or the standard land value, which is the estimated worth of the parcel made by an authoritative private or public assessor. The latter is the basis for governments to formulate land taxation and stabilize real estate market. Generally, land values are studied by urban geographer from these two contexts. As to correlation between land values and location factors, there are a lot of studies in western countries (Asabere, 1981; Asabere *et al.*, 1985; Peiser, 1981; Yeates, 1965). In recent years, some Chinese scholars have paid attention to theory analysis and case studies on standard land value (Shan *et al.*, 1995; Ni *et al.*, 1994). So far, however, there have been no papers on the correlation between market land values and urban location factors in China owing to lack of detail land value data. With a technique of GIS and a method of multiple linear regression analysis, the spatial distribution of Shanghai land values and their correlation with some location factors are examined in this paper.

II. DATA AND METHOD

1. Data

1.1 Sample land parcels and land values

One hundred and sixty-six commercial land parcels leased during 1993– 1994 in Shanghai City are selected as studied samples. The data of land value is floor price, which is the price per unit constructed area agreed when a land parcel was leased. In order to eliminate their price difference caused by inflation during the two years, the values of land parcels leased in 1994 are corrected with the inflation rate of that year.

1.2 Location factors

The following six location factors are selected to analyse their multiple linear correlation with land values of the selected parcels: 1) the distance of each parcel to the city center, which is located at the People Square; 2) the distance to Nanjing Road, which extends from the Bund to Jiangsu Road; 3) the distance to Huaihai Road which extends from Xizang Road to Huashan Road; 4) the distance to the Bund, which extends from the Suzhou River to Shiliupu dock; 5) the distance to the district shopping centers, which includes Xujiahui, Zhongshan Park, Changshou Road, North Sichuan Road– Baoxing Road, Yuyuan, Pudong Avenue– Dongchang Road; 6) the distance to the major public transportation nodes, which includes 6 major nodes such as the People Square, Beizhan, Shanghai Railway Station, the Bund, Wujiaochang, Jing' an Temple, Xujiahui and Dapuqiao.

2. Technique and Method

2.1 Constructing the spatial database for the studied region and sample land parcels

Firstly, with a technique of PC ARC/INFO, the major roads, administrative boundary and the sites of all selective land parcels are constructed by editing data from land use spatial database of 1: 10000 Shanghai Map. Then, the database of land values is constructed in FOXBASE by coding each land parcel. Lastly, the fields such as land values data are added to the property table of the land parcel layer by using joining function of PC ARC/INFO.

2.2 Measuring distance between sample parcels and each location factor

According to the principle that one vector curve consists of countless straight lines which are connected by countless dots, the minimum distance from each parcel to 3 linear location factors such as Nanjing Road, Huaihai Road and the Bund are calculated by programming. The distance from sample parcels to 3 point factors such as the city center, sub-CBD and the public transportation nodes are obtained by changing their coordinates.

2.3 Observing data

Assume that the land value (US$ / m^2) of sample parcel is Y, and the distance to the city center, Nanjing Road, Huaihai Road, the Bund, sub-CBD and the transportation nodes orderly are X_1, X_2, X_3, X_4, X_5 and X_6. The data matrix is as follows:

$$Y_\alpha\ X_{\alpha 1}\ X_{\alpha 2}\ X_{\alpha 3}\ X_{\alpha 4}\ X_{\alpha 5}\ X_{\alpha 6}$$

$$(\alpha = 1, 2, \ldots\ldots, 166)$$

2.4 Constructing a regression model

Suppose that land values, Y, is affected by location factors, X_1, X_2, X_3, X_4, X_5 and X_6, and their internal correlation is linear. The mathematical structure model of the above geographic data is as follow:

$$Y_\alpha = \beta_0 + \beta_1 X_{\alpha 1} + \beta_2 X_{\alpha 2} + \beta_3 X_{\alpha 3} + \beta_4 X_{\alpha 4} + \beta_5 X_{\alpha 5} + \beta_6 X_{\alpha 6} + \varepsilon_\alpha$$

where, β_0, β_1, β_2, β_3, β_4, β_5, β_6 are undetermined parameters and ε_α is a random variable.

With a least square method, the parameters can be calculated and the regression equation will be obtained as follow:

$$Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6$$

where b_0, b_1, b_2, b_3, b_4, b_5, b_6 are partial regression coefficients pertaining to each independent variable.

Finally, the regression equation will be optimized through tests of significance of regression coefficients and deleting some insignificant variables.

III. SPATIAL DISTRIBUTION PATTERNS OF SHANGHAI LAND VALUES

The isogram of Shanghai land values (floor prices) are constructed from the selected 166 sample land parcels (Fig. 1). It shows that the spatial differentiation of Shanghai land values is quite distinct. The prices of those land parcels near the city center reach 1000$ / m^2. But the prices of the outer areas are less than 100$ / m^2. The spatial distribution of the entire city's land values shows the following characteristics:

(1) The highest land value area is located along Nanjing Road, Huaihai Road and the Bund except two polar areas, Xujiahui and Yuyuan. The area with land values more than 700 $ / m^2 is distributed along both sides of Nanjing Road, Huaihai Road, and west to the Bund, which forms 3 long and narrow areas with high land values. Especially, the land values along two sides of Nanjing Road and Huaihai Road just like two ridges facing with each other, extending side by side more than 10 km. The values between these two roads form an obviously

low valley, which slopes from east to west. The land values of the Bund, which extends from Waibaidu Bridge to Shilipu Dock, are obviously higher than those of its north and south side areas. The peak land value area of more than 900$ / m^2 is formed around the intersection of the Bund and Fuzhou Road.

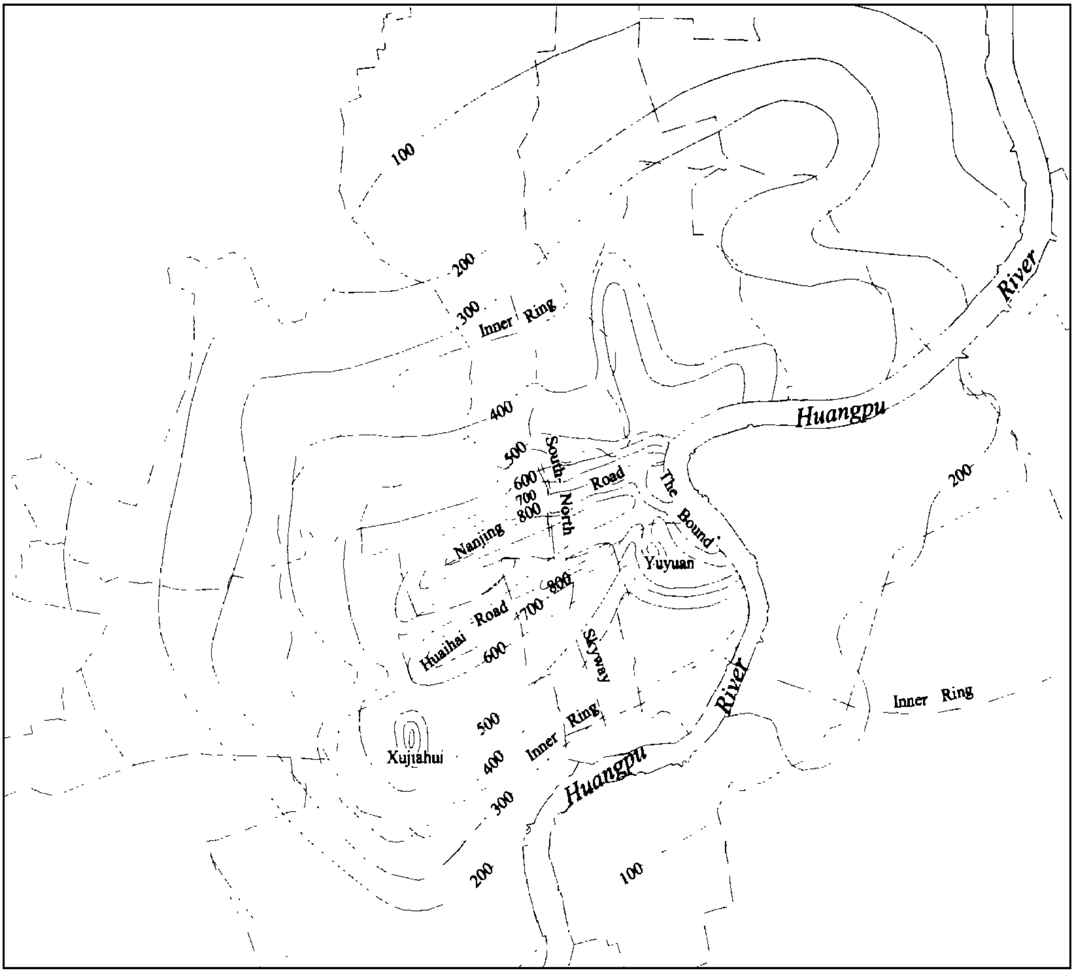

Fig. 1 The isogram of Shanghai land values (floor prices)

(2) The land values of the CBD and the regional commercial centers do not rise obviously. It can be seen from the land value map that the values of the CBD which is located within Beijing Road, Xizang Road, Jinling Road and the Bund are not much higher than those of its surrounding areas, and just the same as those of west Nanjing Road and Huaihai Road. The land values of sub-CBD except Xujiahui and Yuyuan are quite low.

(3) Land values are affected by the main external roads. In fringe areas of the city, there is a tendency that the land value isolines extend outside along the main roads. In the southwest area, for example, the value isolines protrude obviously outside from Xujiahui along North Caoxi Road– Caoxi Road. In northwest area, the isolines basically protrude from Caojiadu a-

long Caoyang Road– Zhenbei Road. In northeast area, the isolines protrude along Siping Road and Yangshupu Road. In west area, there is a tendency protruding along West Yan' an Road– Hongqiao Road.

(4) There is a great difference of land values between Puxi and Pudong. The land values of Pudong are much lower than those of Puxi though there is just the Huangpu River between Puxi and Pudong. It can be observed from the map that the values of Pudong are about 200 \$ / m^2 except that few parcels reach 400 \$ / m^2, and those of the outer areas are only tens of dollar per square meter or even lower. The values of Lujiazui district are also below 300 \$ / m^2 even if it is very close to the CBD. The Bund just facing to it, however, has the values of 700– 900 \$ / m^2. This sharp drop of values between Puxi and Pudong reflects a great difference of their location advantages.

IV. LINEAR RELATIONSHIP BETWEEN SHANGHAI LAND VALUES AND LOCATION FACTORS

By programming and calculating, a regression analysis table (Table 1) and a variance analysis table (Table 2) which show linear relationship between Shanghai land values *(Y)* of samples parcels and the selected location factors (X_1、X_2、X_3、X_4、X_5 and X_6) are obtained.

Table 1 The results of multiple regression analyses

Equation	Corr. Coefficient (R) / Standard error of R	Regress. Coefficient and their tests	Intercept	X_1	X_2	X_3	X_4	X_5	X_6
(1)	0.797 / 124.13	Partial Regress. Coefficient(r)	734.98	–21.66	–36.34	–27.42	–4.61	–1.77	0.18
		Standard error of r	20.06	16.87	15.08	12.13	9.05	10.27	11.23
		T (159)	36.63	–1.28	–2.41	–2.26	–0.51	–0.16	–0.02
		P– level	0.00	0.20	0.02	0.03	0.61	0.87	0.99
(2)	0.797 / 123.37	Partial Regress. Coefficient(r)	735.04	–21.57	–36.36	–27.40	–4.63	–1.67	
		Standard error of r	19.66	15.99	15.00	12.03	8.87	10.00	
		T(160)	37.42	–1.35	–2.43	–2.28	0.52	–0.17	
		P– level	0.00	0.18	0.02	0.02	0.60	0.87	
(3)	0.797 / 123.05	Partial Regress. Coefficient(r)	735.22	–21.89	–36.83	–27.78	–4.50		
		Standard error of r	19.56	15.85	14.67	11.78	8.81		
		T(161)	37.59	–1.38	–2.51	–2.36	–0.51		
		P– level	0.00	0.17	0.01	0.02	0.17		
(4)	0.797 / 123.01	Partial Regress. Coefficient(r)	732.09	–28.70	–35.16	–25.17			
		Standard error of r	18.53	8.52	14.27	10.58			
		T(162)	39.50	–3.37	–2.46	–2.38			
		P– level	0.00	0.00	0.02	0.02			

Table 2 Analyses of variances for multiple regression

Equation	Deviation	Sums of squares	Degree of freedom	Mean squares	F	P - level
(1)	Regress.	4265328	6	710888.0	46.191	0.000
	Residual	2447034	159	15390.2		
	Total	6712363				
(2)	Regress.	4265324	5	853064.8	55.778	0.000
	Residual	2447038	160	15294.0		
	Total	6712363				
(3)	Regress.	4264898	4	1066224.0	70.139	0.000
	Residual	2447465	161	15202.0		
	Total	6712363				
(4)	Regress.	4260926	3	1420309.0	93.859	0.000
	Residual	2451437	162	15132.0		
	Total	6712363				

The multiple linear regression equation is constructed from the regression analysis table as follows:

$$Y = 734.98 - 21.66X_1 - 36.34X_2 - 27.42X_3 - 4.61X_4 - 1.71X_5 + 0.18X_6 \quad (1)$$

It can be known from Table 2 that the p-level of equation (1) is 0, which shows that the equation is highly significant and there is a close linear relationship between selected location factors, (X_1, X_2, X_3, X_4, X_5 and X_6) and land values (Y). The negative signs of the regression coefficients show that all location factors except X_6 have negative relations with land values, which means that the longer the distance from land parcel to the location factors is, the lower the land value is; on the contrary, the higher the land value is. Furthermore, it can be known from the absolute values of each regression coefficient that each location factor has different influence upon Shanghai land values. Nanjing Road, Huaihai Road and the city center are three major location factors affecting the distribution of Shanghai land values. The Bund has little influence on the land value distribution because the absolute value of the coefficient for X_4 is 4.61. The sub-CBD and the public traffic nodes nearly have no influence on it because the absolute value of the coefficient for X_5 is only 1.71 and that for X_6 is 0.18.

A t-test for the coefficients of each factor is conducted. Table 1 shows that only X_2 and X_3 are highly significant and the rest variables are not significant under significance-level of $\alpha = 0.03$. So the unimportant variables can be rejected to construct a more simple linear regression equation. X_6 with the minimum t value is firstly rejected. A new regression equation is constructed:

$$Y = 735.04 - 21.57X_1 - 36.36X_2 - 27.41X_3 - 4.63X_4 - 1.67X_5 \quad (2)$$

It can be seen from Table 2 that regression equation (2) itself is highly significant but X_1, X_4 and X_5 are still not significant under the significance-level of $\alpha = 0.03$. X_5 with minimum t value is rejected and recalculate the data. A new regression equation is obtained:

$$Y = 735.22 - 21.89X_1 - 36.83X_2 - 27.78X_3 - 4.50X_4 \quad (3)$$

X_1 and X_4 in equation (3) are still not significant under the significance-level of $\alpha = 0.22$. After X_4 is rejected a simplified regression model is constructed:

$$Y = 732.09 - 28.70X_1 - 35.16X_2 - 25.17X_3 \qquad (4)$$

Equation (4) is highly significant and all three variables, X_1, X_2 and X_3, are also highly significant under the significance-level of $\alpha = 0.02$. So equation (4) can be thought as the optimized regression equation between Shanghai land values and the selected location factors. Equation (4) shows that Nanjing Road is the first important location factor, the city center is the second one and Huaihai Road is the third one affecting the spatial distribution of Shanghai land values.

V. EXPLANATION OF REGRESSION RESULTS

The relationship between Shanghai land values and the selected location factors is determined by the structure of commercial activities, the characteristics of the CBD and the spatial form of the city.

Nanjing Road and Huaihai Road, both of which stretch more than 10 km, are traditional commercial ribbons and getting more and more concentrated with various commercial activities especially after large-scale renewal in recent years. In addition, there are lots of other commercial streets, such as Middle Xizang Road, East Beijing Road, East Jinlin Road, Middle Henan Road, in the central area of the city. The great concentration of commercial activities in the central area, especially along Nanjing Road and Huaihai Road, results in a steep rise of their land values. So Nanjing Road, the city center and Huaihai Road become the most important location factors affecting the spatial distribution of Shanghai land values.

Compared with the central area, the scale and class of commercial activities in the regional shopping centers except Xujiahui and Yuyuan is quite small. As a planned sub-CBD, Xujiahui has a good accessibility with a subway station and several public bus stations. Yuyuan, the origin site of the city, has been a prosperous market from early days of the city and now has become a tourism and business area mixed with a temple, market and garden. So land values around these two centers are very high. But other 6 sub-CBD have a small scale of commercial activities and nearly have no influence on land values, which must wholly weaken their influence upon land values of the city.

Generally speaking, a transportation node can attract commercial activities and raise its land values. However, the distribution of the transportation nodes does not accord with that of commercial activities. Among eight selected transportation nodes, only three ones, the People Square, the Bund at Yan'an Road and Jing'an Temple, are located within the area of peak land values, while other five ones except Xujiahui almost have no influence on land values. As to the entire city, therefore, influence of the transportation nodes on land values must be little.

As one of the important mark districts of Shanghai, the Bund is a major sightseeing area and a financial street of Shanghai in the future. But it has little influence upon the spatial distribution of land values of the whole city because it is located at the east side of city and adjacent to the low land value area of Pudong.

VI. CONCLUSION

With a regression analysis, the linear relationship between Shanghai land values and selected location factors such as the city center, Nanjing Road, Huaihai Road, the Bund, sub-CBD and the public transportation nodes has been examined. The regression results shows that Nanjing Road, the city center and Huaihai Road are three major factors affecting the spatial distribution of Shanghai land values, which implies that the distribution of Shanghai land values has a highly centrality. Some case studies in western countries have indicated that location factors have different influences on urban land values in a different stage of a city. The development of a city is always affected by both centripetal forces and centrifugal forces. In general, centripetal forces dominate the urban form in its early period. Pulled by centripetal forces, all kinds of intelligent high-class business functions such as finance, insurance, wholesale and the headquarters of multinational enterprises concentrates to the CBD, which results in rising of land values in the city center. During this period, the city center has stronger influence on the distribution of urban land values than other location factors. Centrifugal forces become paramount on urban development during the stage of suburbanization, when population and industries in the city move to suburbs. At this time, some large regional shopping centers, major traffic nodes and amenities may have more influence on urban land values. The results obtained from this paper imply that Shanghai is still on the stage of centripetal development. As to Shanghai, its commercial activities are still concentrated to the city center although its population and industries are moving to suburbs. In recent years, especially with a great scale of urban renewal, the size and class of commercial activities in the city center are upgraded, which results in its much higher land values than those in outer regions.

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