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Using GIS and Hedonic in the modelling of spatial variation of housing price in Xiamen city

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Abstract: Valuing the built environment with the support of GIS and housing price model is an interesting topic because it connects the spatial thinking with economic concerns. In this paper, we chose the ordinary commercial housing in Xiamen City as our research targets, and the technology of GIS and Hedonic price model were used. Xiamen city is a typical coastal city, and from the research result, we found that the distribution of higher housing price was kept consistent with the coastal areas of Xiamen city. Besides, the average housing price of Xiamen inner-island (the old urban island area) was far higher than the outer-island. To reveal the degree of different spatial elements affecting housing price, we chose 21 variables (three types: location characteristic, structure characteristic and neighbourhood characteristic) and measured them in GIS platform. The Hedonic model showed that the main elements that influencing the price of commodity housings in Xiamen included Property Management Fee, Distance to Commercial Center, Distance to Hospital, Distance to Primary School, Near Village or Not, Near Green space or Not, Near kindergarten or Not. At the end of the paper, we provided three suggestions to balance the spatial variation of housing price in Xiamen City.

1. BACKGROUND

Housing, which is one of the most basic human needs, is a hot economic issue and social issues related to people's livelihood. Many factors influence the housing price and many researchers try to reveal the distribution rules on spatial variation in housing price. Some people (Xu, 1997; Jiang and Zhu, 2005; Meng, Zhang et al., 2005; Mei and Li, 2008) used GIS spatial interpolation method to get spatial distribution map and contour map of housing price. Some people (Luo, He et al., 2002) took Lanzhou as a case study and constructed the SD-GIS space-time simulation model to study the space-time distribution changes of residential price. Some (Montero and Larraz, 2009) considered that space in the real estate market is important and official averages do not take into account the spatial correlation of housing price. They proposed the Kriging mean method to estimate mean housing price. Some (Fik, Ling et al., 2003) hold the view that absolute location must be viewed as interacting with other determinants of housing value. They presented an interactive variables approach and tested its ability to explain price variation in an urban residential housing market. Some (Zhang, Meng et al., 2004; Armstrong and Rodríguez, 2006) established the Hedonic price method, studied the relationships between different traffic convenient degree

and house price. Some (Wang, Zheng et al., 2007) constructed Hedonic Model and analysed the degrees how urban public service accessibility influences housing price. Some (Cohen and Coughlin, 2008) revealed the relationship between airport noise level and real estate value. Some (Sedgley, Williams et al., 2008) detected how public school quality influence real estate markets in Howard County, Maryland. Some (Visser, Frank et al., 2008) used Hedonic price modelling to derive different models of property price from which the contribution of the characteristics of the residential environment were estimated. It was demonstrated that an important factor was the accessibility to employment opportunities. Some (Cho, Kim et al., 2009; Cho, Kim et al., 2012) took Knoxville, TN as an example , and focused on the relationship between neighbourhood environment and housing price. They suggested that vacant land should be reasoning to promote its value when the housing price around it rises.

However, from the literature review, we found that geography scholars mainly focused on spatial analysis and less quantitative description about causes. Meanwhile, real estate and city economics researchers mainly focused on the application of Hedonic method to study the external environment influence in housing price (Liu, Yang et al., 2010). In this paper, combined with the technology of GIS and Hedonic model, we systematically analyzed housing price spatial distribution characteristics and influencing factors in Xiamen. We hope that our research and results could provide decision support for urban planning and real estate development, especially in the city which located in the coastal area like Xiamen City.

2. STUDY AREA

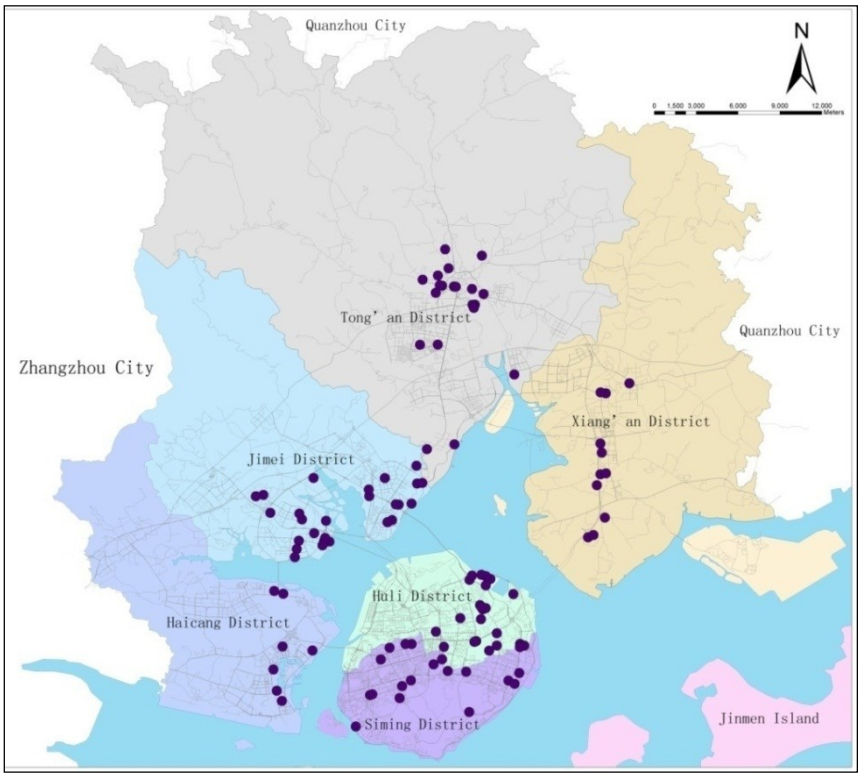

Figure 1. Study Area and the sample data (Xiamen City)

As one of the sub-provincial cities in Fujian Province (one of five municipalities directly under the central government and one of the first batch of five special economic zones in China), Xiamen owns several awards, including 'the United Nations living award', 'international garden city', 'national civilized city', 'national garden city', 'national the most liveable city', and many other honors. Taking built up area of Xiamen as the research scope, which includes Simon District, Huli District and most areas of Haicang District, Jimei District, Tong'an District and Xiang'an District. The administrative divisions of Xiamen city and sample distribution are shown in *Figure 1*.

The sample data is mainly from SouFun real estate website (http://www.soufun.cn/) and real estate advertising on newspapers. We collected 106 housing samples with integrated information. Besides, we used the basic GIS data from the government to establish a GIS database of Xiamen.

3. METHOD

3.1 Technical route

Combined with the GIS spatial analysis technology, we calculated the 21 variables for the three kinds of factors which describe the location characteristic, structure characteristic and neighbourhood characteristic. Using the SPSS software to perform regression analysis, we established an effective Hedonic price model to analyze the degree that characteristics influence the housing price. The technical route is shown as *Figure 2*.

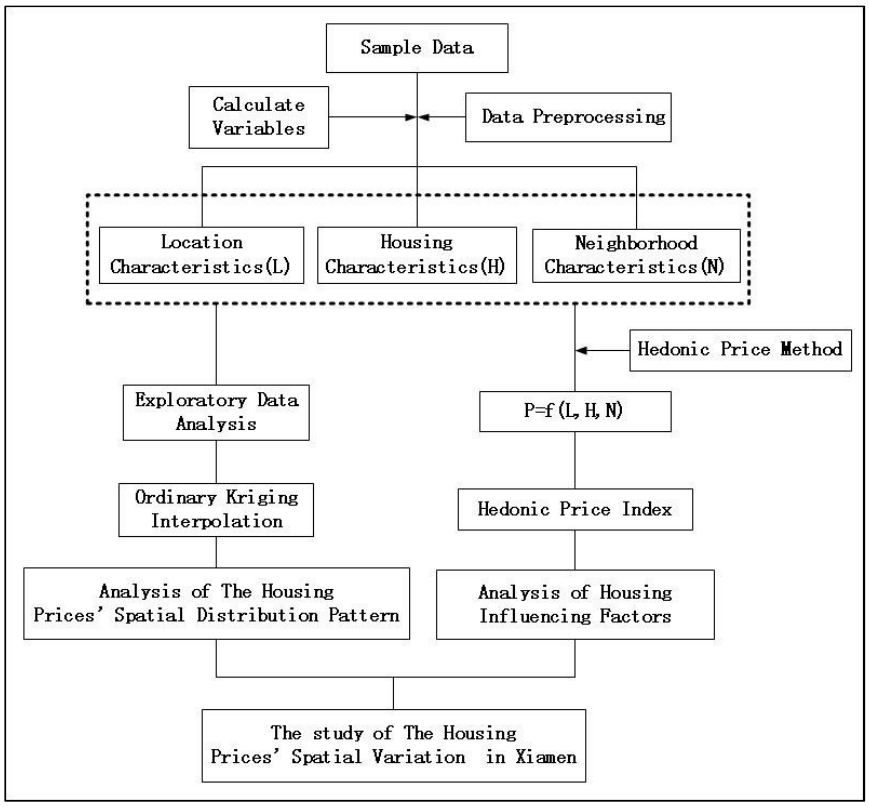

Figure 2. Technical route

3.2 Spatial Autocorrelation Analysis

Spatial autocorrelation analysis was used to test whether the property values in the adjacent space had a significant correlation. High correlation represented that the aggregation of space phenomena exists. Moran's index was commonly used to assess the spatial correlation and its value between -1 and 1. If 1>0, it was positively related to spatial entities showing aggregate distribution. If 1<0, it was negatively related to the spatial entity showing discrete distribution. If 1=0, it was unrelated and spatial entities were randomly distributed. The higher the value, the greater the spatial distribution of the correlation is. Moran's I formula is as *Formula (1):*

$$I = \frac{\mathrm{N}}{\sum_{\mathrm{i}=1}^{\mathrm{N}}\sum_{\mathrm{j}=1}^{\mathrm{N}} \mathrm{W}(\mathrm{i},\ \mathrm{j})} \times \frac{\sum_{i=1}^{\mathrm{N}}\sum_{j=1}^{\mathrm{N}} W(\mathrm{i},\ \mathrm{j})(\mathrm{X_i} - \bar{X})(\mathrm{X_j} - \bar{X})}{\sum_{i=1}^{\mathrm{N}} (\mathrm{X_i} - \bar{X})^2} \qquad (1)$$

In which N represents sample size that participate in analysis, $\mathrm{X_i}$ and $\mathrm{X_j}$ represents the observation at location i and j, and the observation is transaction average price. $\omega(i, j)$ represents the space distance weight, and it can be constructed by the adjacency rule and distance rules.

3.3 Kriging Interpolation

The Kriging method, also known as the spatial local interpolation method, was based on spatial autocorrelation. This kind of method used the structure of semi variable function to create unbiased optimal estimated regional variable values within a limited area. If the results of the variogram and structural analysis showed that the regional variable existed, researchers could take advantage of the method to interpolate or extrapolate the data, and otherwise it was not feasible. The Kriging method will take not only distance when interpolating data, but also the spatial distribution of the known samples and the orientation relationship between known sample's and unknown samples by variogram and structure analysis. The mathematical expression was shown as *Formula (2)*.

$$\mathrm{Z}(\chi_0) = \sum_{i=1}^{n} \omega_i \mathrm{Z}(\chi_i) \qquad (2)$$

In which $\mathrm{Z}(\chi_0)$ represents the values of unknown sample, $\mathrm{Z}(\chi_i)$ represents the values of known sample around unknown sample, ω_i represents the weights of the i known sample to unknown sample, and n represents the number of known sample.

3.4 Hedonic Price Method

Hedonic price method, also known as utility valuation method, was used in this paper. Usually, factors affecting the housing price were divided into

three categories: location (L), structure (S) and neighbourhood (N). The price could be formulated as *Formula (3)*:

$$P = f\left(L, S, N\right) \quad (3)$$

A Hedonic price model often adopts following three basic function forms in the empirical research.

1) Linear model

$$P = a_0 + \sum a_i c_i + \varepsilon \quad (4)$$

As shown in *Formula (4),* in which P represents the average residential price, a_0 is constant, c_i represents characteristic variable of order i, a_i is the characteristic price of variable i and ε is error.

2) Logarithmic linear model

$$InP = a_0 + \sum Ina_i c_i + \sum a_j c_j + \varepsilon \quad (5)$$

As shown in *Formula (5), i*ndependent and dependent variables adopt a logarithmic form. In which c_i is Continuous variable, c_j is neighbourhood attributes which can't take the logarithm. It is 0-1 variable.

3) Semi logarithmic linear model

$$InP = a_0 + \sum a_i c_i + \varepsilon \quad (6)$$

As shown in *Formula (6),* dependent variables adopt logarithmic form while the independent variable adopts a linear form.

4. ANALYSIS

4.1 Spatial Distribution Characteristics

We used the ArcGIS Geostatistics function to evaluate the spatial distribution of housing price in Xiamen. Figure 3 showed that the housing price was higher in the southern part of the island than the northern. Both east and west were lower than the middle and the curve present inverted "U". The housing price at Xiamen showed a very different non-linear distribution characteristic.

With ordinary Kriging interpolation method, we performed spatial interpolation analysis of sample data. Spatial distribution of ordinary housing price in Xiamen is shown as Figure 4.

The housing price in Xiamen city generally showed a strong single-center distribution pattern. The price in island area was a gradient decreasing process from the edge of the island to the inside area. The housing price of outside area was much lower than Xiamen Island. The highest price was around Zhongshan Road area. This area was the earliest commercial center in Xiamen city, where was a place close to the Gulangyu scenic zone and people gathered there in a long history.

Besides, it formed a housing price sub-center around Yuandang lake and train station. Administrative Centre and external traffic hub were located in these two areas where transport was convenient, scenery was beautiful and public service configuration was complete. In the outside island region, both Haicang District and Jimei District had a relatively higher level housing price than Tong'an District and Xiang'an District.

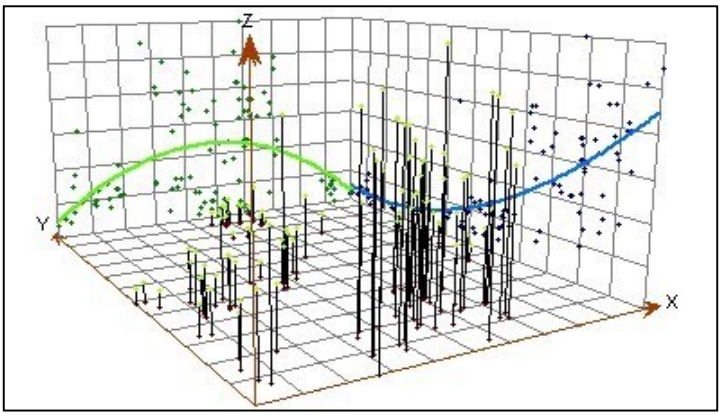

Figure 3. Trend surface of commodity housing price in main urban areas of Xiamen

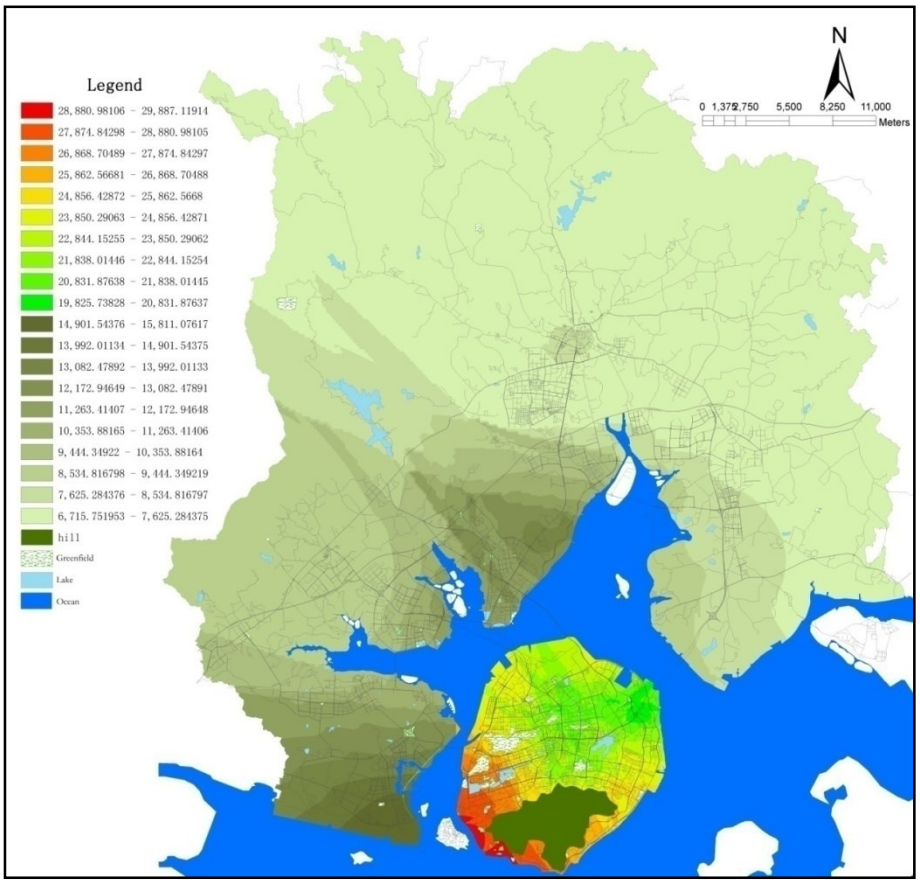

Figure 4. Spatial distribution of commodity housing price in main urban areas of Xiamen

4.2 Spatial Autocorrelation

According to the *Formula 1*, we used ArcGIS Spatial autocorrelation tool to calculate the Moran's I index of these 106 samples. The Moran's I index was 0.30 and the Z score was 16.34, which indicates that the housing price were clustered, rather than dispersed.

Using ArcGIS cluster and outlier analysis tool, we calculate the Local Moran's I index of housing price in Xiamen. The results were divided into 4 types, as shown in *Figure 5*. The red sample point indicates the price both this sample point and around it was higher than the average price of all

values. It's called local high value aggregation (high-high). There were 32 this kind of housing and they were all located in Xiamen Island where infrastructure was complete and the commercial environment was prosperous. The blue sample point indicated that the price of the sample point and around was lower than the average price of all values. It's called local low value aggregation (low-low). There were 29 this kind of sample and they all located in outside in Xiang'an District, Tong'an District and Jimei District. There was only one purple point and located in the junction area between JImei District and Tong'an District. It represented price to this point is higher than the average price of all values, but the housing price around was lower than the average price. It's called local high heterogeneous (high-low).

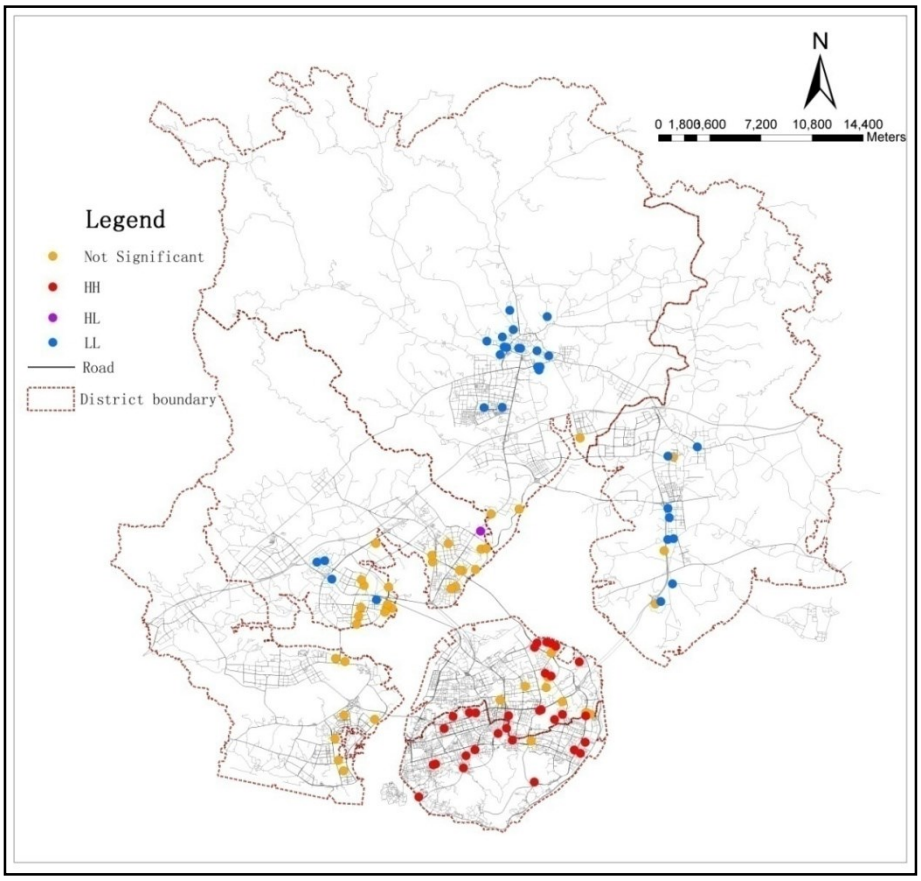

Figure 5. LISA of commodity housing price in main urban areas of Xiamen

4.3 Influencing Factors

Table 1. Characteristic variables of houses and their meanings

Category	Characteristic variable	Description and measurement of variable
Location	NextToOcean (X_1)	The closest distance from the ocean（m）
	NextToCC (X_2)	The closest distance from the commercial center（m）
	NextToKPSchool(X_3)	The closest distance from the key primary school（m）
	NextToKSSchool (X_4)	The closest distance from the key secondary school (m)
	NextToAC (X_5)	The closest distance from the administrative

		centre (m)
	NextToHospital (X_6)	The closest distance from the hospital (m)
Surrounding	PublicTransportservice (X_7)	Bus line numbers within 500m
environment	PShoolService (X_8)	If there is a primary school within 800m (0 or 1)
	SSchoolService (X_9)	If there is a secondary school within 1000m (0 or 1)
	KGService (X_{10})	If there is a kindergarten within 1000m (0 or 1)
	GreenFieldEffect (X_{11})	If there is green field within 500m (0 or 1)
	RailwayEffect (X_{12})	If in the 500m buffer area of railway (0 or 1)
	BankService (X_{13})	If there is a bank within 500m (0 or 1)
	VillageEffect (X_{14})	If there is a village within 500m (0 or 1)
Housing	BuildingArea (X_{15})	Building area (m^2)
	FloorArea (X_{16})	Floor area（m^2）
	Parking (X_{17})	Parking space
	Households (X_{18})	Households
	GreenRate (X_{19})	Green ratio (%)
	FAR (X_{20})	Plot ratio
	PropertyManagementFee (X_{21})	Property management fee（Yuan/month· m^2）

We selected 21 variables for our study. The variables were selected on the base of literature review and the availability of data. We classified the variables into three types: location characteristic, structure characteristic and neighbourhood characteristic. The characteristic variables are shown as in *Table 1*.

4.4 Hedonic Modelling

The standard method for estimating Hedonic price function was parameter method. First, we determined the functional form. Then, we needed to select the appropriate estimation method. Last, we needed to fit the sample data. In order to facilitate the estimation of parameters and interpretation, we made the hypothesis that the relationship between price characteristics was linear. Many researches adopt standard simple functions, such as a linear model, semi logarithmic model and logarithmic model, etc. The reason for selecting these function form was that the traditional least square estimation methods was convenient to statistical inference and hypothesis testing. In this paper, we estimated the housing characteristic price or marginal price through the model, then took the corresponding market analysis.

In Economic theory, there were no explicit rules to specify which function forms and feature variables Hedonic adopted for Hedonic housing modelling. Thus, this study compared the three kinds of functional forms in order to select a suitable model. Meanwhile, we monitored the co-linearity between variables by variance inflation factor (VIF).

Table 2 showed the parameter comparison of three functions. Linear model multiple correlation coefficient R was 0.901. It demonstrated that the fitting precision of linear model was better than the other two. Thus, we choose linear model to study the relationships between housing price and housing characteristics. According to the partial regression coefficient in the regression equation, we removed the factors that significant level larger than

10%. Combined with variance inflation factor (VIF) inspection, we weeded out the multicollinearity factors. Finally, there were 7 variables selected in the model. After running the regression analysis, the results were as shown in the *Table 3*.

Table 2. Comparison of three functions

Function type	R	R^2	Adjusted R^2
Linear model	0.901	0.812	0.800
Log-linear model	0.897	0.805	0.790
Semi-logarithmic model	0.874	0.764	0.754

Table 3. Regression coefficient analysis

	Non-standardized coefficient		Standardized coefficient			
Variable	B	Std Error	Beta	t	Sig.	VIF
Constant	5274.659	1446.784		3.646	.000	
PropertyManagementFee (X21)	4880.947	445.076	.613	10.967	.000	1.270
NextToCC (X2)	-.602	.153	-.218	-3.939	.000	1.247
NextToHospital (X6)	1.190	.387	.197	3.071	.003	1.675
NextToKPSchool (X3)	-.271	.127	-.123	-2.139	.035	1.354
VillageEffect (X14)	-2501.633	968.019	-.139	-2.584	.011	1.173
GreenFieldEffect (X11)	2974.278	1024.754	.163	2.902	.005	1.289
KGService (X10)	2572.500	1004.815	.137	2.560	.012	1.159

5. RESULTS

The regression coefficients for 7 characteristic variables of the linear model could be obtained by regression analysis. We calculated the housing Hedonic price model of Xiamen, as shown in *Formula (7)*:

$$Price=5274.659-0.602X_2-0.271X_3+1.19X_6+2572.5X_{10}+2974.278X_{11}-2501.633\ X_{14}+4880.947\ X_{21} \quad (7)$$

According to the results of regression analysis, we could find the main elements that influence the price of commodity housings in Xiamen: PropertyManagementFee (X_{21}), NextToCC (X_2), NextToHospital (X_6), NextToKPSchool (X_3), VillageEffect (X_{14}), GreenFieldEffect (X_{11}), KGService (X_{10}).

1) Proximity of the commercial centers (X2)

Generally speaking, commercial centers were the most active areas of a city as they provided various urban services and consumption choices for urban residents, which made it very convenient for people to live. Theoretically, the housing price in the surrounding area was relatively higher. It could be seen from the Hedonic price model that the variable coefficient of the distance to commercial centers was -0.602, suggesting that the distance from housing to business centers was inversely proportional to the housing price. With the distance between dwellings and business centers expanding, the residential price would fall. More specifically, every 1

kilometre of the increase in distance would cause 602 RMB (Yuan) loss in sale price.

2) Proximity of the hospitals (X6)

With the improvement of living standards, people paid more attention to medical and health care than before. As an important kind of public service, medical care provided protection for the life and health of the residents. "Time is life", the distances between dwellings and hospitals measured the residents' medical convenience. However, the coefficient of the model doesn't reflect the relationship that the houses price increases among with the distance increasing. The most reason is the models don't differentiate the needs of health care service between different age groups. The young people are strong and seldom go to the hospital. They usually will never take hospital into account even reject live close to hospital. Meanwhile the elderly people are more often go to the hospital. Considering the access of the data, the Hedonic model didn't specially research the age structure of families then ignored the elderly's preference close to hospital. In the Hedonic price model, the variable coefficient of hospitalization was 1.19, and it meant that the sale price would increase 1,190 RMB as the distance to hospitals increase 1 kilometer.

3) Proximity of the key primary schools (X3)

Education was the foundation of the nation, which was related to the quality of people and long-term development of the country. As the high-quality education resources were limited and unevenly distributed, many parents in China rent or even bought houses near key schools in order to offer their children with better education. As can be seen from the above Hedonic price model, the key primary schools had a positive effect on housing price and the sale price would decrease 1,190 RMB per kilometer as the distance to provincial-demonstrated primary schools increased.

4) Near village or not (X14)

With the increasing development of Chinese economy, the process of urbanization was becoming faster and faster. Urban construction and urban area expanded to the outlying regions, which made "villages surrounded by cities" become the most common phenomenon. The area that had not been urbanized could be found in the urban area, and this was called "village in the city". Cities were often close to rural settlements in the outreach process. The rural lands possessed features such as a high building density, a low greening rate, narrow and hindered streets, poor sanitation and so on because of land property restrictions and lack of reasonable and effective planning. Urban infrastructure and public service facility could not reach the whole city, so the development of urbanized area close to villages was kind of limited. As can be seen from the above Hedonic price model, villages had a negative effect on residential lands' externality. The average price of the premises near the village was 2,501.633 RMB lower than the ones far away from the village.

5) Near Greenland or not (X11)

As the living standard improves and awareness of environmental protection enhances, residents were more willing to purchase houses with comfortable environment. Being the open space of a city, public green lands possessed functions like landscape, airing and leisure. They were provided with social, economic and ecological value, and made the comfortable living and working environment accessible to residents. It could be concluded from the Hedonic price model that public green lands had a positive effect on urban residential lands' externality. The average price of the housings close

to greenbelts was 2,974.278 RMB higher than the ones far away from the green space.

6) Near kindergartens or not (X10)

It was not suitable for children to attend school through a long trip as they are at such a young age. On one hand, the overlong distance to kindergarten may cause safety problems. On the other hand, it would aggravate the parents' burden in picking up their children. As an important kind of neighborhood service, the kindergartens were supposed to be arranged near residential districts because of the object restrictions they served. In the Hedonic price model, the variable coefficient of kindergarten was 2,572.5, suggesting that the average price of housings near kindergartens was 2,572.5 RMB higher than that of housings far away from kindergartens.

7) Property management level (X21)

Property cost was a symbol of property management level. Decent property management indicated high-quality living conditions. As can be seen from the regression coefficients of characteristic variables, the property management level had a great influence on premises price. Housing prices would increase 4,880.947 RMB as long as the property cost increased 1 RMB.

Other variables, such as building area, household number, parking digits, volume rate, greening rate and so on, had little influence on housing price. It meant that the scale of premises can hardly affect people's consuming choice, while the parking digits, volume rate, greening rate, etc. were prescribed in urban controlling detailed planning and could meet people's needs of living.

6. DISCUSSION

1) Single-central city polarization development

Since the reform and opening up 30 years ago, the construction of Xiamen island had been highly concentrated, tended to saturation, presented as a typical single-central spatial structure (He, Qiu et al., 2007). Dense population, traffic congestion, landscape degradation, overtop property price had become a common problem on the main island, and urban construction or supporting facilities outside main islands had large lagged behind. The proportion of area between the main island and the outside was 1:11, and the proportion of population density was 11:1. 65% of the jobs distribute in the main island, and large cultural，educational and body health facilities, port airports，railway stations and the important traffic facilities were almost located in the main island. Polarization effect of the island was very obvious.

In recent years, some sea-crossing passages (such as JiMei Bridge, Xiang'An tunnels) have built. The infrastructures, for example, the port and the new railway station, have begun to locate outside the island. The construction of these functional facilities expands the city scale, however, the corresponding public facilities fail to timely follow-up and the city has not formed the strong anti-magnetic function. As a result, the broadening function of the outer island strengthens the single central polarization effect through the "diffusion - echo" effect, and the single-central structure is difficult to break at present. Single-central city structure decides Xiamen housing price on the spatial distribution pattern of a single center.

2) Unbalanced allocation of public facilities

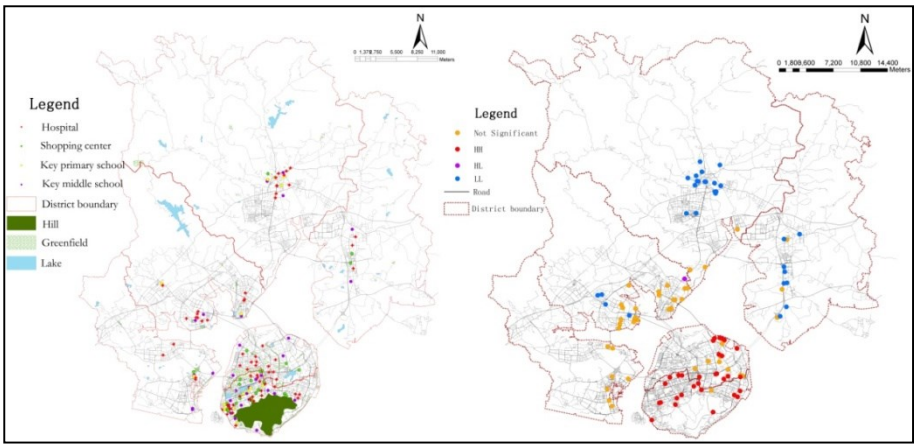

Figure 6. Compare of public service and housing price' LISA

Some researchers (Basu and Thibodeau, 1998) thought that housing price had spatial correlation for two reasons. One was that neighbouring areas tended to the same sequence development, resulting in adjacent area had the similar structural characteristics, such as residential size, building age, internal and external design style, etc.. Another reason was the adjoining property of enjoying the same convenience degree of public service facilities. Good accessibility of public service facilities was the important premise ensuring the residents' quality of life (Wang, Zheng et al., 2007). Although single-central polarization would bring a lot of problems, such as traffic congestion, environmental degradation, but high quality public service facilities owned much stronger appealing, which made people unconsciously live around the centre of the city. Consequently, these would lead to high housing price in the core area. As shown in *Figure 6*, the island highly concentrated the public service facilities, and the housing price was also high in the island area.

For a long time, Xiamen citizens had a traditional thought —"prefer a bed in the island, not a room outside the island ". In order to change this situation, we must improve the quality of new shopping, transportation, health care, education and other supporting facilities outside the island.

3) Geographical spatial partition

The gulf made the Xiamen city separated, and caused the urban spatial structure discontinuity. Due to the gulf division, the links between outside areas and the main island are bridges and tunnels. As shown in *Table 4*, the direct link between HaiCang, JiMei and Main Island was earlier (Year 1999 and Year 2008) through Haichang Bridge and Jimei Bridge. The direct link between Xiang'an and the main island is relatively late, and there is no direct link between Tong'an and the main island.

Table 4. The General situation of traffic projects connecting Xiamen Island and outside

Traffic project	Traffic time	Designed traffic capacity	Connection area	Passing vehicles
Haicang Bridge	December 30, 1999	5 ten thousand pcu /Day	Huli-Haicang	Car
Xinglin Bridge	September 1, 2008	3.38 ten thousand pcu/day	Huli-Jimei	Car /train
Xiamen Bridge	December 19, 1991	2.5 ten thousand pcu/day	Huli-Jimei	car

Jimei Bridge	July 1, 2008	5.5 ten thousand pcu/day	Huli-Jimei	car
Xiang'an Tunnel	26 April, 2010	5.2 ten thousand pcu/day	Huli-Xiang'an	Car

4) Coastal landscape effect

It was obviously that coastline, shoreline resources owned special or extra value because of its beautiful scenery. For Xiamen city, because of its pleasant climate, clean environment, rich historical and cultural background, the value of coastal landscape effects are even greater. A large number of market demand made the real estate price in coastal area higher than other area in Xiamen city. More specifically, in the island, the housing price was decreasing from the coastal line to the inside island, however, in the outside island, the housing price was increased from the inside to the outside coastal area.

7. CONCLUSION

This article discussed the spatial distribution in housing price in Xiamen City. It revealed the different spatial pattern of Xiamen housing price and found that the location characteristic, neighborhood characteristic and building characteristics had significant influences in housing price. At the end of the paper, we provide three suggestions. One is to strengthen the rapid transportation construction of the main island and outside, to shorten the space and time distance of the city area, to enhance the different geographical location accessibility, to strengthen the residents travel convenience. The second is to be optimized allocation of public service resources in the city area, especially to strengthen the regional and high quality public service facility configuration outside the island. The last is to weaken the polarizing effect of the island, to relocate parts of the city functions such as foreign transportation, administrative office, entertainment, business and trade of the island.

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REFERENCES

Armstrong, R. J. and Rodríguez, D. A. (2006). "An evaluation of the accessibility benefits of commuter rail in eastern massachusetts using spatial hedonic price functions", *Transportation,* 33(1), 21-43.

Basu, S. and Thibodeau, T. G. (1998). "Analysis of spatial autocorrelation in house prices", *The Journal of Real Estate Finance and Economics,* 17(1), 61-85.

Cho, S., Kim, J., et al. (2012). "Neighborhood spillover effects between rezoning and housing price", *The Annals of Regional Science,* 48(1), 301-319.

Cho, S. H., Kim, S. G., et al. (2009). "Spatially-varying effects of rezoning on housing price", *Review of Urban & Regional Development Studies,* 21(1), 72-91.

Cohen, J. P. and Coughlin, C. C. (2008). "Spatial hedonic models of airport noise, proximity, and housing prices", *Journal of Regional Science,* 48(5), 859-878.

Fik, T. J., Ling, D. C., et al. (2003). "Modeling spatial variation in housing prices: A variable interaction approach", *Real Estate Economics,* 31(4), 623-646.

He, Z. Z., Qiu , G. C., et al. (2007). "Research of xiamen urban morphology development based on space syntax analysis", *Huazhong Architecture,* 25(3), 106-108.

Jiang, F. and Zhu, D. L. (2005). "A gis-based study on spatial distribution of land prices, the case of residential land prices in beijing", *Economic Geography,* 25(2), 199-202.

Liu, D. H., Yang, Y. C., et al. (2010). "Study on the spatial distribution of housing price and its influencing factors in chengdu based on gis and hedonic model", *Journal of Anhui Agricultural Sciences,* 38(29), 16519-16523.

Luo, P., He, S. F., et al. (2002). "A case study of space-time simulation of lanzhou's urban housing prices using the sd-gis model", *JOURNAL-LANZHOU UNIVERSITY NATURAL SCIENCES,* 38(4), 125-130.

Mei, Z. X. and Li, X. (2008). "Spatial analysis of houses' price in dongguan based on esda and kriging techniques", *Economic Geography,* 28(5), 862-866.

Meng, B., Zhang, J. Q., et al. (2005). "Application of spatial analysis to the research of real estate:Taking beijing as a case", *Geographical Research,* 24(6), 956-964.

Montero, J. M. and Larraz, B. (2009). "Estimating housing prices: A proposal with spatially correlated data", *International Advances in Economic Research,* 16(1), 39-51.

Sedgley, N. H., Williams, N. A., et al. (2008). "The effect of educational test scores on house prices in a model with spatial dependence", *Journal of Housing Economics,* 17(2), 191-200.

Visser, P., Frank , V. D., et al. (2008). "Residential environment and spatial variation in house prices in the netherlands", *Tijdschrift voor economische en sociale geografie,* 99(3), 348-360.

Wang, S. T., Zheng, S. Q., et al. (2007). "Spatial accessibility of housing to public services and its impact on housing price: A case study of beijing's inner city", *Progress in Geography,* 26(6), 78-85+147-148.

Xu, X. H. (1997). "An analysis on the spatial distribution characters of commercial residence price in shanghai", *Economic Geography,* 17(1), 80-87.

Zhang, W. Z., Meng, B., et al. (2004). "Influence of traffic passages on housing spatial expansion and local residents' selection of housing location--a case study of beijing", *Scientia Geographica Sinica,* 24(1), 7-13.