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Analysis of the Spatial Effect of Urban Expressway on House Price

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ABSTRACT
Transportation infrastructure can affect the house price by influencing the traffic accessibility of the location. The urban expressway is an important part of the transportation infrastructure, which should have a certain impact on the house price. This paper analyses the spatial effect of urban expressway on house price by using geographically weighted regression model. Results show that the house price has a significant spatial autocorrelation effect, and the estimation result of the geographically weighted regression model is superior to the traditional hedonic model, and the spatial influence range and elastic coefficient of the expressway transportation cost on the house price are estimated. In addition, time cost can reflect transportation cost better than path cost.

Keywords: *House price, urban expressway, spatial effect, geographically weighted regression*

1. INTRODUCTION

The development of transportation infrastructure and the resulting drop in transportation costs and increase in accessibility levels are closely related to changes in house values. As residents' demand for motor vehicle travel increases rapidly, the construction of transportation infrastructure (viaduct, tunnel, expressway, etc.) can improve the travel efficiency of private cars, thus improving the accessibility of the region or city and effectively relieving the traffic pressure in the region[1]. On the other hand, transportation infrastructure can continuously promote the flow and combination of factors of production, which would have a significant impact on house prices[2].

In this paper, we analyse the spatial impact of urban expressway on house prices. Taking Desheng expressway in Hangzhou as an example, geographically weighted regression model is used to analyses the spatial impact of Desheng expressway on house prices and summarize the influence mechanism of urban expressway on the spatial distribution of house prices.

In the scope of the analysis, we find that the coefficient of the impact of expressway time cost on house prices is unevenly distributed in space, and the overall residential price is negatively correlated with the time cost. The relationship between the path cost and the house price differs from ranges, the spatial influence range and elastic coefficient of the expressway transportation cost on the house price are given in section 3.

2. DATA AND METHODOLOGY

2.1. Study Area

Desheng Expressway is the most important "one horizontal" in the Hangzhou expressway network system, as shown in Figure 1. According to the 2016 “Reply of the State Council on the Hangzhou City Master Plan”, a multi-level and multi-type urban integration system is required to be established soon, combining different modes of transportation to facilitate the different modes of transportation. "Hangzhou City Comprehensive Transportation Special Plan 2007-2020 (2018 Revision) also proposes to speed up the construction of the road network to form a fully functional, reasonably graded and well-serviced road network with the expressway as the skeleton. Superior traffic interconnectivity makes Desheng Expressway one of the important skeletons of the Hangzhou Expressway network.

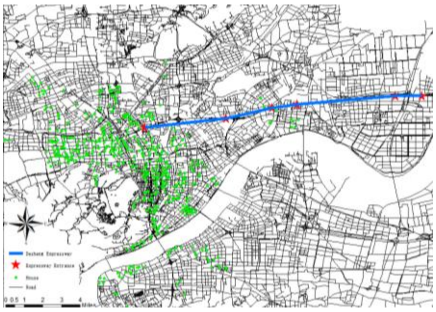

Figure 1 Map of Desheng Expressway and house samples

2.2. Data

We use transaction data on house prices from the administrative database of Transparent House Sales (http://www.tmsf.com/). In China, new house price data is more affected by policy regulation than the power of market, thus it cannot fully reflect the relationship between market supply and market demand, so in this research we focus on second-hand house price. In this paper, the average transaction price of second-hand house in each community in the main urban area of Hangzhou, in 2015, is calculated by considering the community as a single research object, and 463 house price sample data are obtained.

For the housing characteristic data, the research center which the author belongs to has regularly collected long-term and in-depth research data on the Hangzhou real estate market to ensure the accuracy of housing data[3-5]. The research team regards community residents, neighborhood committees and property staff as the research objects, and obtained primary research data through questionnaires and interviews.

In this paper, the accessibility data is measured by the travel cost, and we measure the travel cost into two types: path cost and the time cost, where path cost refers to the shortest real distance between two geographic objects, and the time cost refers to the shortest travel time between two geographic objects, such as the travel time cost from a community to POI. By cooperating with government transportation department, the research team obtained the necessary data for this research.

2.3. The Geographically Weighted Regression Model

In the house market literature, hedonic regressions are most commonly used to determine the price of a property as a function of its attributes[6]. Geographically weighted regression is one statistical technique which can be used to examine the spatial variability of regression results across a region and so inform on the presence of spatial non-stationarity[7]. Recently, the GWR model has been applied to estimate the impact of transportation infrastructure on housing prices, such as rail transits[8], road infrastructure [9]and so on.

In this paper, the GWR model is established as follows:

$$P_i = \beta_0(u_i, v_i) + \sum_{j=1}^{k} \beta_j(u_i, v_i) X_{ij} + \varepsilon_i \qquad (1)$$

In which,

P_i : Transaction price of second-hand house;

(u_i, v_i) : Spatial weight coefficient of the ith community which is calculated by bi-square method;

X_{ij} : The jth explanatory variable of the ith community;

ε_i : Random error term.

The details of explanatory variables in the model are given in Table 1.

Table 1 Variable Definitions

Variable	Description	Expected sign	Value range
House price	The average price of second-hand house in each community(yuan / m^2)	/	9251-40360
DS	The cost of traveling from the community to the intersection of Desheng Expressway (km or sec)	—	0.22-3.49 56-1780
DT	The shortest distance from the community to the nearby subway station (km)	—	0.20-4.94
Age	Average house age in one community(years)	—	5-33
Out green	The level of the external environment of the community, on a score of 1-5 from worst to best	+	2-5
In green	The level of the internal environment of the community, on a score of 1-5 from worst to best	+	1-5
Bus	The number of bus lines within 1000 meters near the community (line)	+	5-70
Life	The level of Market, supermarkets, hospitals, post offices, banks within 1000 meters near the community, on a score of 1-5 from worst to best	+	1-5
Edu	Whether there is an kindergarten, elementary school, junior high school, and high school within 1,000 meters near the community, each item is 1 point, a total of 4 points	+	2-4
Sport	Whether there is an elderly activity room, fitness facilities, basketball court, tennis court, swimming pool, badminton court, table tennis court, children's amusement park within 1000 meters near the community, each item is 1 point, a total of 8 points	+	1-5
Property manage	The level of Community property management service, on a score of 1-5 from worst to best	+	1-5
Westlake distance	The closest distance from the community to the West Lake (km)	—	1.2-13.1

3. RESULTS

3.1. Spatial Autocorrelation Analysis

The inverse distance weight interpolation method can obtain the spatial differentiation pattern of house prices in the study area (Figure 2). From the figure, it can be intuitively judged that the spatial distribution of residential price samples is not uniform, but It has the feature of spatial dependence and spatial heterogeneity.

Using Arcgis spatial autocorrelation tools to analyze the relationship between the house price data and its location, the results are shown in Figure 3, Figure 4. The Global Moran I index is 0.2365, indicating that the housing price data has a strong degree of spatial autocorrelation; the Z score is 33.57, indicating that the result is 33.57 times the standard deviation value, and the result falls to the right of the normal distribution curve, indicating that the probability that the result is created by a random process is less than 1%.

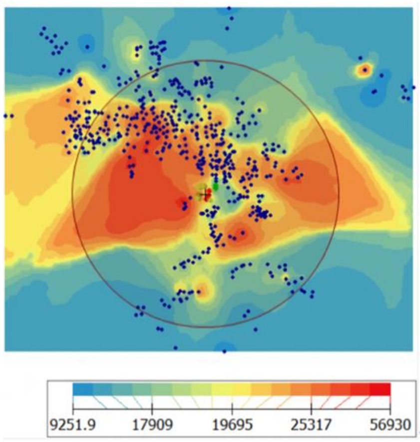

Figure 2 House price spatial differentiation pattern (unit: yuan / square meter)

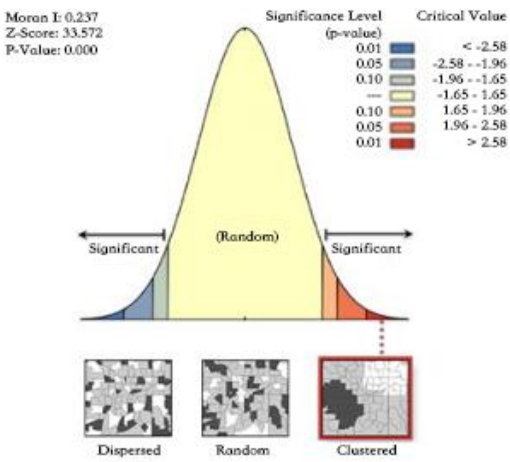

Figure 3 Global autocorrelation coefficient score graph

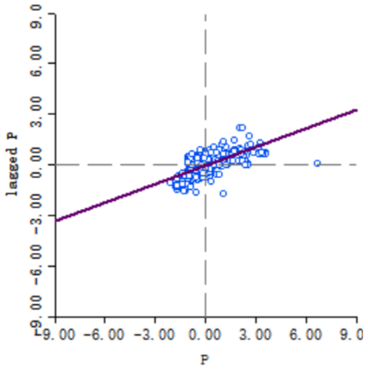

Figure 4 Global Moran I Index graph

3.2. Comparison of Two Types of Transportation Cost

In this research, two different types of travel costs are considered to better reflect the actual transportation cost, path cost and time cost. By comparing the adjusted goodness of fit estimated by the GWR method between the two models, the function with the best goodness of fit after adjustment is selected. The comparison results are shown in the Table 2. According to the result, the adjusted model with the time cost has the best fitting goodness, which fits our expectations.

Table 2 R2 comparison of two types of transportation cost in different model forms

Forms	Linear function form	Logarithmic function form	Semi-logarithmic function form
path cost	0.8572	0.8994	0.8989
time cost	0.8762	0.9026	0.9011

In addition, as can be seen from the table, among the three function forms, the model with logarithmic function form has the highest fitting goodness parameter value after adjustment, thus the logarithmic function form is selected as the function form of this study.

The specific model is as follows:

$$LnP_i = \beta_0(u_i, v_i) + \sum_{j=1}^{k} \beta_j(u_i, v_i) LnZ_{ij} + \sum_{j=1}^{k} \beta_j(u_i, v_i) X_{ij} + \varepsilon_i \qquad (2)$$

3.3. Variance Analysis

We use variance analysis method on the GWR model to check whether there is a significant statistical performance difference between the traditional global regression (OLS) model and the GWR model. The results are shown in Table 3. It can be seen from the table that the F value is 7.6993 and the F value is much greater than 1, indicating that there is a significant statistical performance difference between the global regression model and the GWR model. And the residual error of the GWR model is much smaller than that of the OLS model, indicating that the GWR model fits the data better than the OLS model.

Table 3 ANOVA result graph

Source	SS	DF	MS	F
Global Residuals	5.256	216.000		
GWR Improvement	4.286	76.763	0.054	
GWR residuals	0.970	137.237	0.007	7.699

SS: Sum of squares of deviation from mean/DF: Degree of freedom/MS: Mean square/F: F-statistic

3.4. Results of the GWR Model

Based on the previous research experience and the current sample size, the house sample of expressway time cost less than 30 minutes is taken as the research object for geographic weighted regression analysis. The regression results are shown in Table 4. It can be concluded from the results that the impact of the same variable on housing prices is not evenly distributed in space, but there are obvious differences. This difference is reflected in the sign and magnitude of the regression coefficient. For example, the lower quartile value of the house age coefficient in Table 4 is -0.198, and the upper quartile value is 0.101. That is, the impact of house age in different spatial locations on residential prices may be significantly different, and may have diametrically opposite residential prices Impact.

Taking into account the impact of expressway time cost on house price, the above model is estimated to obtain the estimated value of the expressway time cost parameters at 463 observation points, the minimum value of which is -0.097, the lower quartile is -0.029, and the median is -0.001, the upper quartile is -0.028, and the maximum value is 0.200 It shows that at a certain spatial location, for every 1% increase in expressway time cost, the house price will fall by 0.097%; for another spatial location, for every 1% increase in expressway time cost, the house price will increase by 0.200%.

Table 4 GWR model regression coefficient result table (Within 30 minutes)

Variable	Min	Lower quartile value	Median	Upper quartile value	Max
Intercept	8.476	9.953	10.234	10.483	10.962
DS	-0.097	-0.029	-0.001	0.028	0.200
DT	-0.182	-0.022	0.004	0.033	0.123
Age	-0.198	-0.101	-0.068	-0.042	0.252
Out green	-0.068	-0.017	-0.001	0.014	0.122
In green	-0.080	0.010	0.025	0.034	0.062
Bus	-0.010	0.001	0.009	0.017	0.046
Life	-0.068	-0.036	-0.016	0.021	0.124
Edu	-0.074	-0.014	0.013	0.072	0.148
Sport	-0.027	0.008	0.016	0.034	0.078
Property manage	-0.022	0.001	0.009	0.058	0.157
Westlake distance	-0.597	-0.245	-0.210	-0.195	0.106
AICc			-483.542		
R square			0.915		
Adjusted R square			0.902		

4. DISCUSSION

It can be observed from Figure 5 that the influence coefficient and P-Value of expressway path cost on house prices is unevenly distributed in space, and there are obviously more observation points with negative coefficient estimates. The overall house price is negatively correlated with expressway path cost. The higher the path cost, the lower the house price. In most of these areas, the impact of expressway path cost on house price is negatively correlated, that is, the farther the community is from the expressway, the higher the house price, while a small area is positively correlated, that is, the closer the community is to the expressway, the house price lower. It can be intuitively seen from the figure that within a certain path cost, the higher the path cost of the expressway, the higher the house price. This may be caused by the negative externality of the residential price caused by the noise and environmental pollution caused by the expressway. In addition to certain traffic costs, the higher the expressway traffic cost, the lower the house price. This can be explained by the improvement of the accessibility of the expressway to the house and the improvement of the location characteristics. To estimate the spatial influence range, we filter out the sample points with the influence coefficient value close to 0 in the results, and analyze the average path cost to estimate the influence range. As a result, the influence range in this study is about 0.39km.

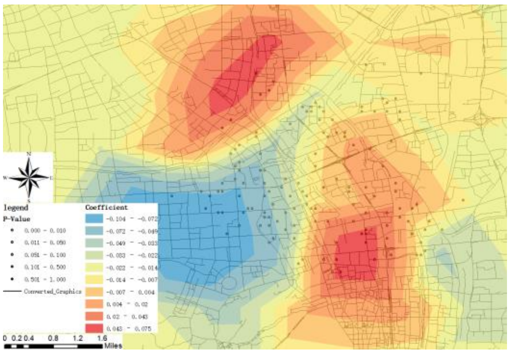

Figure 5 Spatial distribution map of the effect of expressway path cost on house price

5. CONCLUSION

This paper studies the spatial impact of urban expressway on house prices. Taking 2015 Hangzhou second-hand housing transaction data as the study case, the hedonic price model is estimated by geographic weighted regression (GWR) method. Results show that the house price has a strong spatial autocorrelation effect, and the estimation result of the geographically weighted regression model is superior to the traditional hedonic model. The coefficient of the impact of expressway transportation cost on house prices is unevenly distributed in space, and the overall house price is negatively correlated with the expressway transportation cost. The median value of its elastic coefficient is -0.001%. In the range where the path cost is less than 0.39km, the higher the transportation cost, the higher the house price; when the path cost is greater than 0.39km, the higher the transportation cost, the lower the house price. In addition, time cost can reflect transportation cost better than path cost.

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