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Spatial Autoregressive Model of Commodity Housing Price and Empirical Research

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Abstract

Based on spatial econometric model, the article selects the panel data of eight cities around Beijing from 1998 to 2009. It tests whether there is spatial dependence among cities on commodity housing price. The main influence factors of the housing price are further analyzed. Finally, the housing prices of the 8 cities are tested by the Granger. The results show that there is significant spatial dependence between cities on the housing price. The factors that affect the commodity housing price include spatial factor, urban residents' disposable income factor, population factor, land price factor and living space factor. Granger test shows that there is one-way relationship of Beijing to Tianjin, Shijiazhuang, Shenyang, Changchun and Jinan. The conclusions establish the theoretical foundation for the formation mechanism of the housing price and offer references for engineering project pricing in real estate and government macro regulation.

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Keywords: house price; spatial econometrics; spatial dependence; engineering; equilibrium price supply and demand

1. Introduction

With the rapidly development of real estate industry in China recently, increasing housing price couldn't be controlled although the government has launched a series of real estate policies and social security systems. This article is focus on the commodity housing price among cities existing spatial dependence based on the spatial econometrics. The auto regression models are established by spatial econometrical methods, and examined by the panel data of eight cities around Beijing from 1998 to 2009. The main factors of the increasing housing price have been analyzed. And then the influenced direction of the housing price among cities has been discussed Granger-causality Test. The conclusions establish the theoretical foundation for the formation mechanism of the housing price and offer references for government macro regulation.

2. On Selection of the Variable

This article chooses average selling price of the commodity house as the dependent variable. The selection of independent variables is based on the equilibrium price theory and the factors of influencing commodity housing price from many scholars. Supply factors include land cost. Demand factors include gross domestic product (GDP), urban residents' disposable income factor, population factor and living space factor [1]. In addition, the article draws ideas from spatial econometrics and argues that space factor plays a key role of commodity housing price.

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3. Construction of Spatial Autoregressive Model of Commodity Housing Price

The final commodity housing price is fixed by supply and require in housing market [2]. This approach is to establish a supply and demand equilibrium price model. The parameters of model are obtained though getting maximal utility between the developers and the consumers [3]. Finally, the housing price has been gotten by supply and demand equilibrium.

The demand function model in the housing market is:

$$H_{Q_d} = \beta_0 + \beta_1 P_h + \beta_2 X \tag{1}$$

The supply function model in the housing market is:

$$H_{Qs} = \partial (P_h - C) \tag{2}$$

H_{Qd} is demand for commodity house; P_h is commodity housing price; X is other demand variable; $\beta_0, \beta_1, \beta_2$ is variable coefficient; H_{Qs} is supply of commodity house; ∂ is variable coefficient; C is house cost.

According to equilibrium theory, equation is obtained as follows:

$$P = a + \partial C + \beta X \tag{3}$$

The function (3) is the function of the commodity housing price. Equilibrium price (P) is dependent variable; a is constant.

The function (3), formally, is the multivariate linear regression model about commodity housing price with its influence factors. But some spatial economists such as Anselin (1988) believe that using the data sample usually refer to different space and time and these data almost exist various degrees of spatial correlation in the realistic economic research [4]. Model in classical econometrics usually satisfy the postulate of unrelated sequences, zero mean and homoskedasticity. Whereas meeting with panel data, classical econometric model cannot give an exact explanation of spatial dependence. As a result, the model can't deals with these problems in the realistic economy. If the space factor is not considered, the conclusion is not in accord with the realistic economy. It is essential to conclude the spatial econometrics into categories of the housing price researching [5].

In spatial econometric model, spatial dependence models mainly include spatial lag model and spatial error model [6].

Spatial lags model (SAR) expression:

$$Y = \rho W_1 Y + \beta X + \varepsilon \tag{4}$$

ρ is the spatial regression coefficients； W is spatial weight matrix; X is number matrix of; β is the coefficient of independent variable; ε is random disturbance term.

Spatial error model (SEM) expression:

$$Y = \beta X + \varepsilon \text{，} \quad \varepsilon = \lambda W_2 + u \tag{5}$$

W_2 is spatial weight matrix of disturbance term; λ is spatial autoregressive coefficient of ε ; u is normal distribution.

Combining with the above analysis on commodity housing price, the spatial econometric model will be set up as follows:

The spatial lag model (4) in study case can be expressed as:

$$PH = a_0 + \rho W_1 \cdot PH + \beta_1 IC + \beta_2 POP + \beta_3 GDP + \beta_4 SL + \beta_5 PL + \varepsilon \tag{6}$$

The spatial error model (5) in study case can be expressed as:

$$PH = a_0 + \beta_1 IC + \beta_2 POP + \beta_3 GDP + \beta_4 SL + \beta_5 PL + \lambda W_2 + u \tag{7}$$

4. Empirical Research

4.1. Sample, variable selection and data source

4.1.1. Sample selection

The article selects the panel data of eight cities around Beijing from 1998 to 2009. These cities contain Beijing, Shijiazhuang, Tianjin, Taiyuan, Hohhot, Jinan, Shenyang and Changchun.

4.1.2. Variable selection and data source

- Commodity housing price (PH). It is usually described by average selling price of the commodity house.
- Residents' disposable income (IC). It is described by per capita disposable income of urban residents.
- Urban population (POP). It is described by the end of the total population.
- GDP. It is described by the actual amount of GDP for each city.
- Living space (SL). It is described by per capita living space.
- Land prices (PL). It is described by land exchange price index.

The data mainly comes from Statistical Yearbook for each city, National Economic and Social Development of these cities, and China Real Estate Statistics Yearbook. Part of data comes from China Statistical Yearbook and China City Statistical Yearbook.

4.2. Construction of space weight matrix

The construction of space weight matrix adopts two methods: longitude-latitude coordinate and relative position. At present, it is not accurate to set up space binary adjacency matrix method by relative position. So this article is used for the former method to establish this matrix:

$$W = \begin{bmatrix} 0 & 0.2500 & 0.2000 & 0 & 0.2000 & 0.2000 & 0.2000 & 0 \\ 0.2500 & 0 & 0.2500 & 0 & 0 & 0.2500 & 0 & 0.2500 \\ 0.2000 & 0.2000 & 0 & 0.2000 & 0.2000 & 0 & 0 & 0.2000 \\ 0 & 0 & 0.3333 & 0 & 0.3333 & 0 & 0 & 0.3333 \\ 0.2500 & 0 & 0.2500 & 0.2500 & 0 & 0 & 0.2500 & 0 \\ 0.2500 & 0.2500 & 0 & 0 & 0 & 0 & 0.2500 & 0.2500 \\ 0.3333 & 0 & 0 & 0 & 0.3333 & 0.3333 & 0 & 0 \\ 0 & 0.2500 & 0.2500 & 0.2500 & 0 & 0.2500 & 0 & 0 \end{bmatrix}$$

4.3. Spatial correlativity test

Researching spatial autocorrelation usually be used for Moran's I. By the range of Moran's I, it can be known whether there are some regularities when researching the commodity housing price among cities. The results are as follows:

Table 1 The whole of Moran's I of commodity housing price

nobs	Moran's I	E(I)
96	0.2796	-0.0399
Var(I)	Z statistics	P value
0.0046	4.7286	0.000

The above result shows that from 1998 to 2009, commodity housing prices of cities are positively associated with a spatial correlation coefficient of 0.2796. The probability of refusing spatial assumption is 0.000, which shows that there is significant spatial relativity among regional commodity housing prices.

4.4. The selection of regression models

Next are results of the selection of regression models by LM test results.

Table 2 LM test results

Index	Statistics	P
LM-lag	32.4247	0.000
robust LM-lag	8.974247	0.003
LM-error	31.0552	0.000
robust LM-error	7.6073	0.006

The results of LM test shows that it is better to use the spatial lag model， which is in accord with the indexes robust LM-lag and robust LM-error themselves confidence interval.

4.5. Parameter estimation about spatial lag model

Better effect of regression can be achieved by using stepwise regression method. This model takes the housing price as dependence variable and the other five variables as independence variable including residents' disposable income, urban population, GDP, Living space and land prices. The maximum likelihood is used to get the parameter estimation. The following conclusions are made:

Table 3 Regression results and process of spatial lag model by stepwise regression

index	IC	POP	GDP	SL	PL	R^2	Adjusted R^2
$Y = f(IC)$	0.71820 （11.5811）					0.7871	0.7079
$Y = f(IC, POP)$	0.7099（12.7103）	0.2348（4.6705）				0.8248	0.7858
$Y = f(IC, POP, GDP)$	-0.0798 (-0.4402)	-0.3838 (-2.7193)	0.6201 （4.5246）			0.8534	0.8403
$Y = f(IC, POP, SL)$	0.7864 (10.9215)	0.2358 (4.7498)		-0.2437 (-1.7472)		0.8300	0.7888
$Y = f(IC, POP, SL, PL)$	0.7645 (10.9144)	0.2606 (5.3130)		-0.3330 (-2.3956)	0.5587 (2.5321)	0.8407	0.8042

Table 3 results show that goodness-of-fit value is higher. But remarkable changes of IC and POP are indistinctive to keep GDP as a variable. When choosing SL and PL as variables, goodness of fit (R^2) and revised R^2 are enhanced, also t-test is changed significantly. Finally, the regression function of factors about influenced housing price is identified.

$$\hat{Y} = -5.1595 + 0.344 * W * \hat{Y} + 0.7645 * IC + 0.2606 * POP - 0.3331 * SL + 0.5587 * PL$$

Specific model is estimated as follows:

```
Dependent Variable =            PH
R-squared          =    0.8407
corr-squared       =    0.8042
sigma^2            =    0.0425
Nobs,Nvar          =     96,     6
log-likelihood     =         13.79837
# of iterations    =      3
min and max rho    =   -1.0000,    1.0000
total time in secs =    0.1090
time for optimiz   =    0.0930
time for lndet     =    0.0150
No lndet approximation used
*************************************************************
Variable        Coefficient  Asymptot t-stat    z-probability
con               -5.159491        -4.953770         0.000001
IC                 0.764487        10.914372         0.000000
POP                0.260579         5.312954         0.000000
SL                -0.333048        -2.395643         0.016591
PL                 0.558734         2.532129         0.011337
W*dep.var.         0.343995         5.306602         0.000000
teta               0.996894         3.823919         0.000131
```

Fig. 1 Results of ML estimation of spatial lag model of commodity housing price

Fig .1 is the results of ML estimation of spatial lag model of commodity housing price. It shows that urban population (POP) and residents' disposable income (IC) are significant influenced factors. Meanwhile, living space(SL) and land price(PL) is significant in 95% confidence interval which is comparatively lower than POP's and IC's. But regression coefficient of land price is up to 0.56, which is next below IC's.

4.6. Granger causality test

As for the influencing factors of increasing housing price, two main aspects can be divided: one is internal factor including POP, IC, SL, PL and so on; The other is from rising house prices of its neighbors'. Housing price among cities exist spatial correlations. The influenced directions of the housing price among cities will be discussed by Granger causality Test.

4.6.1. Integration Test

Before Granger causality test, the date should be made unit root test whether it is steadiness sequence.

Table 4 Results of integration test of commodity housing price

Content	D(location)	P value	D(location,1)	P vaule	D(location,2)	P value
Beijing	3.218292	0.9980	-2.515158	0.0195	-5.446355	0.0001
Tianjin	3.676214	0.9991	-0.244326	0.5698	-4.925353	0.0003
Shijianzhuang	0.925033	0.8885	1.410725	0.9464	-5.928823	0.0001
Taiyuan	4.956679	0.9999	0.071178	0.6800	-2.878619	0.0110

Hohhot	2.969927	0.9968	0.754584	0.8555	-5.083450	0.0056
Shenyang	2.695357	0.9948	-1.597736	0.1006	-3.340859	0.0045
Changchun	3.896211	0.9994	-0.193666	0.5890	-5.740934	0.0001
Jinan	6.639511	1.0000	0.170534	0.7119	-5.304599	0.0002

It is clear from the above table results that the commodity housing price of each city exists second order integration. It means that housing price has integration relationship among the cities and their sequence is smooth. The article can further make Granger causality test.

4.6.2. Granger causality test

The next will test for the direction of the commodity housing price among cities.

Table 5 Results of Granger causality test of the commodity housing price between Beijing and other seven cities

Content	Lags	F statistics	P value
Tianjin→Beijing Beijing→Tianjin	2	1.68409 10.4904	0.2760 0.0162
Shijiazhuang→Beijing Beijing→Shijiazhuang	2	3.47613 8.28349	0.1132 0.0259
Taiyuan→Beijing Beijing→Taiyuan	2	2.18699 0.10805	0.2078 0.8996
Hohhot→Beijing Beijing→Hohhot	2	3.40262 0.05478	0.1167 0.9473
Shenyang→Beijing Beijing→Shenyang	2	0.14431 6.67307	0.8691 0.0388
Chuangchun→Beijing Beijing→Chuangchun	2	1.24448 16.7079	0.3800 0.0114
Jinan →Beijing *Beijing →Jinan*	2	0.00047 10.0508	0.9832 0.0132

From the Granger causality test results above, the conclusion can be made that there isn't exist the Granger causality in any direction between Beijing and Taiyuan, which means that Beijing's housing price changes can not significantly cause these two cities'. From the table, it is obviously that there exists one-way Granger causality among Beijing Tianjin, Shijiazhuang, Shenyang, Changchun and Jinan.

5. Conclusion

- The housing price of eight cities around Beijing exist significantly correlation by Moran's I test.

- The main influence factors of the increasing housing price include spatial factor, urban residents' disposable income factor, population factor, land price factor and living space factor by spatial lag model.
- Granger causality test shows that there is one-way relationship of Beijing to Tianjin, Shijiazhuang, Shenyang, Changchun and Jinan. It is not this relationship of Beijing to Taiyuan or Hohhot. This results prove that housing price of Beijing is a dominant position among around cities.

Therefore, increasing housing price of each city is influenced by its own economical Characteristics. In addition, it is affected though the housing price of around cities. So that, it is important significance to adjust Beijing's commodity housing price for its surrounding cities'. The conclusions establish the theoretical foundation for the formation mechanism of the housing price and offer references for engineering project pricing in real estate and government macro regulation.

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