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Research on Spatial Spillover Effects and Influencing Factors of Urban Housing Price in China Based on Gravity Weights

Yalan Sun*

College of Management, Shanghai University, Shanghai 201800, China
**Corresponding author e-mail: 19802132610@qq.com*

ABSTRACT. *This paper collects panel data from the real estate markets of 35 large and medium-sized cities in China from 2009 to 2018, combines geographic regions and economic indicators, constructs a dynamic gravitational space weight matrix, and calculates Moran's I and Local Moran's I indexes to determine whether there is a spillover effect between cities. Finally, the dynamic spatial Dubin model is used to study the spatial spillover effect of China's urban housing prices and the degree of influence of various factors on China's housing price spillover effects under different weight matrices.The results show that the housing prices of 35 large and medium-sized cities in China are roughly in a ladder-like pattern of high in the southeast and low in the northwest; the housing prices of the 35 cities have obvious positive spatial correlation.*

KEYWORDS: *real estate prices, spatial weight matrix, spatial econometric mode*

1. Introduction

With the development of social economy, the links between cities are getting closer. Due to the imbalance in the level of development between cities, factors such as socio-economic level, population mobility and city size will affect housing prices. When housing price changes spread spatially and fluctuate with housing price fluctuations in other cities, there will be a spillover effect of housing prices.

Regarding the research on house price spillover effects, MacDonald [1] and Meen [2] were the first to study house prices in various regions in the UK and found that house prices as a whole conduct from the southeast to the middle and the north, confirming the existence of spatial spillover effects. Balcila [3] found that in South Africa and other regions, housing prices between cities are also closely related, and there is a strong spillover effect.Subsequent research documents mainly rely on theories such as global vector autoregressive model and Granger causality test to verify the spillover effects of housing prices in different countries and regions.

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When describing the influencing factors of house price spillover effects in the early days, Bramley [4] proposed that housing prices are a function of population, real estate supply, geographic location and economic factors. Later, Meen[2] and Wood[5] noticed the impact of spatial arbitrage trading and wealth transfer on housing prices. In addition, information transmission will also affect spillover effects through indirect channels, such as the herd effect.

Therefore, studying the structural characteristics and spillover effects of housing prices in Chinese cities, and the impact of different factors on housing price spillover effects, are of great significance for judging the trend of housing prices in Chinese cities and formulating and implementing corresponding policy measures.

2. Methodology

2.1 Analysis of spillover transmission mechanism

Spatial spillover mainly involves population, economic and information flows, and changes in the direction and intensity of spillover will all lead to corresponding connections between different cities. With regard to urban housing prices, demographic and economic changes, and market participants' decision-making information will also affect the changes in housing prices in different urban spaces. Furthermore, the research hypothesis of this paper: the transmission of housing price spillovers between different regions is through the three mechanisms of population mobility, social economy and information transmission. The conduction mechanism is shown in Figure 1.

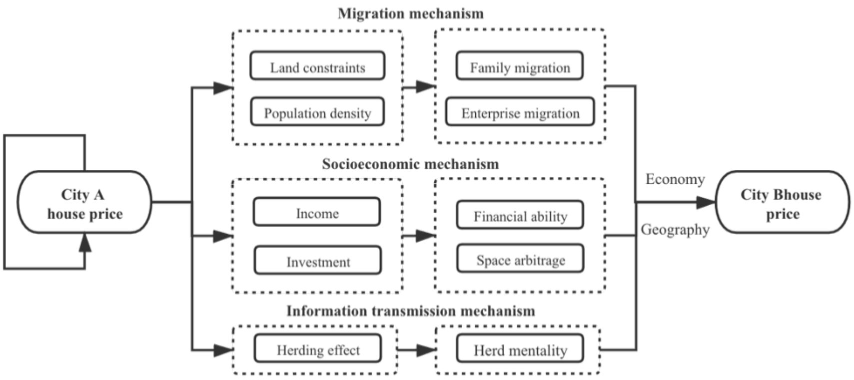

Figure. 1 Flow chart of target tracking process

In terms of migration mechanism, housing price spillover includes two influencing factors: population density and land constraints. When families move, the population continues to flow from city A to city B, the latter's market supply and

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demand increase, and housing prices are also raised. When companies move, due to rising land costs and labor costs, some companies will relocate to cities with lower housing prices, and the supply and demand in the real estate market of the latter will also change, which will affect the housing prices of the latter.

In terms of socioeconomic mechanism, it mainly includes income and investment. During the relocation process, it can be found that when a city's income level changes, it will increase the housing purchasing power of the city's residents and trigger the housing demand of immigrants, leading to an increase in the level of housing prices in the city. At the same time, the increase in urban income will also have a cross-regional impact on housing prices in other cities.

The information transmission mechanism affects the real estate market by influencing the psychological expectations of real estate market participants. Since the basic value of real estate cannot be accurately estimated, participants may expect the housing prices in their own cities based on market conditions in other cities. Therefore, housing price fluctuations can spread through the herd effect. From the perspective of space arbitrage, Meen [2] pointed out that due to the rapid spread of housing price information in adjacent areas, buyers with high investment demand will look for space arbitrage opportunities. The spatial arbitrage will have an impact on the housing prices of nearby cities and make them rise until a new price equilibrium is formed, thereby generating a spatial spillover effect of housing prices.

2.2 Spatial weight matrix

The spatial weight matrix is usually expressed as an n*n-order non-negative matrix W. The larger the weight value, the stronger the spatial dependence between regions. Defining the spatial distance is the prerequisite for spatial measurement analysis. The distance is mainly reflected by the spatial weight matrix, which represents the form of influence between regions. For the sake of robustness, this paper considers geographical distance, economic distance and other factors to set the spatial weight matrix when setting the spatial weight.

Considering only spatial geographic distance or economic distance has certain limitations. Therefore, the two factors can be comprehensively considered to construct a weight matrix. The stronger the economic strength of the two regions, the stronger the economic ties; the closer the distance between the two regions, the greater the weight. The gravitational weight matrix also takes into account the geographic distance and economic distance between spatial units, and can more comprehensively measure the relationship between the two places. The closer the geographical distance between the two spatial units and the stronger their economic strength, the greater the spatial correlation between the two places (Peng Chong, 2014) [6]. The specific weight setting form is as formula (1):

$$WD_{ij} = \begin{cases} \frac{1}{d_{ij}^2}, i \neq j \\ 0, i = j \end{cases} \tag{1}$$

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Among them, d_{ij} is the distance between regions i and j, X_i and X_j represent the GDP per capita of regions i and j.

When the economic development of the two regions is relatively good, the numerator is large. If the distance between the two regions is relatively close and the denominator is small, the weight is large; when the economic development of the two regions is weak and the distance is relatively long, the weight is small; Regional economic development is better, but the distance is far, the larger the denominator will restrict the numerator, and the weight will not be too high. Therefore, it can be seen that the weight is affected by two factors.

2.3 Model construction

With the development of the spatial panel data model, LeSage[7] found that if both the explained variables with spatial lag effects and the influence on the explained variables are considered, the spatial dubin model can be used. This model can be regarded as the special form of the spatial lag model and the spatial error model. This paper establishes a spatial dubin model to measure the different effects of various variables on housing price spillovers, and finally gives relevant policy recommendations based on the conclusions of empirical research. The measurement model constructed in this paper is as formula (2):

$$\begin{aligned} lnhp_{it} = {} & \alpha_0 + \lambda W lnhp_{it} + \mathrm{lnincome}_{it}\beta_1 + \mathrm{lninvest}_{it}\beta_2 + l\mathrm{nland}_{it}\beta_3 \\ & + lndensity_{it}\beta_4 + lnyq_{it}\beta_5 + W\mathrm{lnincome}_t\delta_1 + W\mathrm{lninvest}_t\delta_2 \\ & + Wl\mathrm{nland}_t\delta_3 + Wlndensity_t\delta_4 + Wyq_t\delta_5 + u_i + v_t + \varepsilon_{it} \end{aligned} \tag{2}$$

In formula (2): In order to avoid heteroscedasticity, all variables with larger values are taken as natural logarithms. lnhp_{it} is the N×1 explained variable; W is the spatial weight matrix; lnincome, lninvest, lnland, lndensity, and lnyq are the explanatory variable matrices including income, investment, land constraint, population density and herd effect, respectively.

λ is the spatial lag regression coefficient, which represents the impact of changes in housing prices in neighboring cities on changes in local housing prices. β is the direct effect of the local explanatory variables on the changes in local housing prices. δ is the regression coefficient of spatial error, that is, the influence of each explanatory variable of neighboring cities on the changes of local residential housing prices. ui, vt and εit are the spatial effect, time effect and disturbance term vector respectively. When δ≠0 and ρ≠0, the above model is the spatial Durbin model. Subsequent LR test and Wald test can be used to determine whether the spatial dubin model will degenerate into a spatial autoregressive model or a spatial error model.

Considering the availability of data and the representativeness of the samples, this paper selects 35 large and medium cities as the research objects. The data of each variable comes from the 2010-2018 China City Statistical Yearbook, the statistical bulletin of each city and the WIND database. The geographic distance between different cities in the spatial weight matrix used in this paper is calculated by using the Euclidean distance based on the projection coordinates converted from the city's latitude and longitude coordinates in ArcGIS 10.2.

3. Results and discussion

3.1 The spatial distribution of housing prices in China

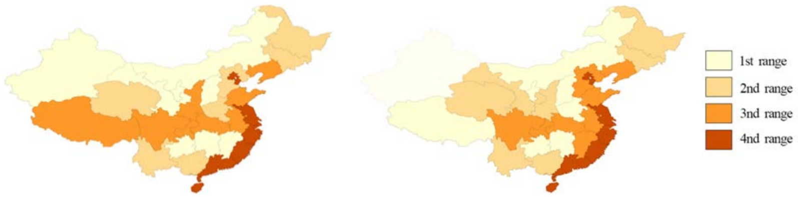

Figure. 2 Quartile map of house sales prices in 2010 and 2018

The quartile maps of the spatial distribution of housing prices in my country in 2010 and 2018 are on the left and right, which can show the distribution of housing prices in various regions in a macroscopic view. In the above figure, the map is divided into 4 colors corresponding to each In different housing prices, the housing price corresponding to the dark area is the highest, and the housing price is decreasing sequentially, and the housing price corresponding to the lightest area is the lowest.

With the changes in the spatial distribution in the figure, we can conclude that my country's housing prices are roughly in a ladder-like pattern with high in the southeast and low in the northwest. With the continuous development of my country's economy, provinces with high housing prices are gradually gathering in southeastern China.

3.2 The spatial pattern and evolution of city housing prices

This paper selects two indexes, the global spatial autocorrelation described by the global Moran’s I index and the local spatial autocorrelation reflected by the Moran scatter plot. The Moran’s I index analyzes the degree of spatial dependence within a total spatial range; the other Moran scatter plot describes the degree of similarity between a spatial unit and its domain, and can indicate the degree to which each local unit obeys the global general trend.

The global Moran index is defined as follows:

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i-\bar{x})(x_i-\bar{x})}{S^2\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \quad (3)$$

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Among them, $S^2 = \frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n}, \bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$ is the arithmetic mean of x_i, representing the observed value in the i-th spatial unit, n is the number of spatial units, and w_{ij} is the spatial weight matrix element.

The value of Moran's I index is between [-1,1]. When the index is greater than 0, it means that there is a positive spatial correlation in economic behavior. When the index is close to or equal to 0, there is no spatial correlation. When the index is less than 0, it means negative. Correlation.The greater the absolute value of the Moran index, the higher the degree of spatial correlation, and vice versa.

Definition of local Moran index is defined as follows:

$$I_i = \frac{(x_i-\bar{x})}{S^2} \sum_{j=1}^{n} w_{ij} \left(x_j - \bar{x}\right) \quad (4)$$

The meaning of the local Moran index is similar to that of the global Moran index. A positive I^i means that the high (low) value of area i is surrounded by surrounding high (low) values. A negative Ii means that the high (low) value of area i is surrounded by surrounding low (high) values.

The above has concluded that China's housing prices have obvious spatial agglomeration. Later, the paper uses related spatial statistics Moran’s I and Local Moran’s I to test and analyze, and quantify the spatial correlation and correlation degree of housing prices from a theoretical perspective.

Table 1 Moran index under three spatial weight matrices

Year	Gravity Weight Matrix	
	Moran index	P value
2010	0.347	0.000
2011	0.358	0.000
2012	0.354	0.000
2013	0.356	0.000
2014	0.349	0.000
2015	0.338	0.000
2016	0.344	0.000
2017	0.353	0.000
2018	0.353	0.000

The above table shows the Moran’s I index test results of house prices. It can be seen from the data that the Moran index is greater than 0, and there is a significant positive correlation between housing prices. As China's real estate market continued to tighten control policies in the later period, demand began to overflow, so the positive correlation of housing prices gradually began to weaken.

Because the research object of this paper is 35 large and medium cities, the amount of data to calculate the local Moran index between each other is huge, so the Moran scatter plot is used to describe the spatial correlation between each other.

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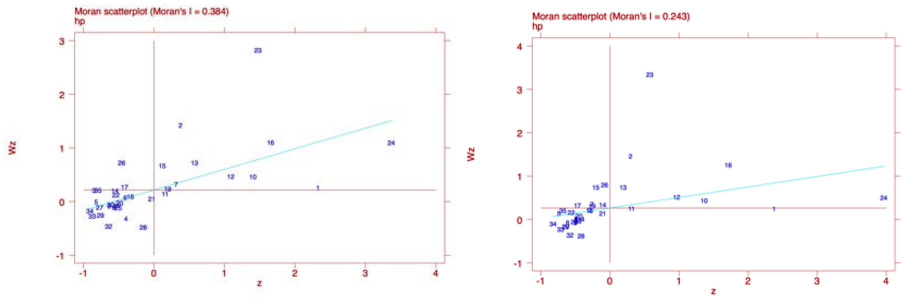

Figure 3 Scatter plot of housing prices in 2010 and 2018

Comparing Figures 3, most cities are concentrated in the first and third quadrants, showing a trend of high-high agglomeration and low-low agglomeration, and this trend becomes more obvious over time.

3.3 Regression results

Based on the gravity weight matrix, this paper uses Stata to estimate the panel data of 35 large and medium-sized cities from 2010 to 2018. The regression results are shown in following table.

Table 2 Regression results of spatial dubin model

Variable name	Direct effect	Indirect effect	Total effect
Lnincome	0.199 (1.49)	0.520** (2.88)	0.720*** (5.34)
Lninvest	0.0103 (0.37)	0.0875 (0.82)	0.0978 (0.86)
Lnland	0.0151 (1.27)	0.0980** (3.00)	0.113** (2.98)
Lndensity	0.412** (3.12)	-0.591 (-1.33)	-0.179 (-0.35)
Lnyq	0.00364 (0.13)	-0.140* (-2.16)	-0.137 (-1.88)
Spatial rho	0.394*** (5.61)		
R^2	0.8777		

*t statistics in parentheses， * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$*

The spatial rho value is 0.394. This means that housing prices have a significant positively correlated spillover effect. In terms of direct effects, population density has a significant impact on local residential housing prices. Among them, when other conditions remain unchanged, for every 1% increase in the population, the

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local housing price will rise by 0.412%. The increase in the population and the increase in demand for local housing products will stimulate home ownership and increase the popularity of real estate, thereby promoting the rise in housing prices.

In terms of indirect effects, income, land constraints, population density and herd effects have significant effects on local residential housing prices.

Residents' income has a significant positive impact on residential housing prices in neighboring large and medium-sized cities, and a higher income level will increase the housing demand of residents in neighboring large and medium-sized cities.Especially in the context of strict control policies in some cities, development companies anticipate the flow of housing demand and are willing to bid for land at a higher price, and at the same time promote housing prices in neighboring large and medium-sized cities;

Land constraints and population numbers also have a significant positive impact on residential housing prices in neighboring large and medium-sized cities. The shortage of urban land resources has caused some companies to invest or develop other cities, which has caused housing price spillovers and increased housing prices. The increase not only increases residents' local demand for housing purchase, but also affects neighboring large and medium-sized cities, leading to positive spillover effects and rising housing prices.

The herd effect has a negative impact on residential housing prices in neighboring large and medium cities.

The enhancement of the local herd effect will promote the development of the local real estate market, and surrounding companies or residents may converge and invest in the local real estate market, thus causing a negative spillover effect of foreign housing prices.

4. Conclusion

This paper analyzes the characteristics of the temporal and spatial evolution of housing prices in 35 large and medium-sized cities in the past 9 years, and uses the spatial Dubin model to test the changes in urban housing prices and the degree of influence of various factors on housing prices.

There is an obvious spatial correlation between house price changes in 35 large and medium-sized cities in my country, which also shows that changes in regional house price distribution are not random, but show spillover effects on surrounding areas or affected by spillover effects from neighboring areas.

Through the use of spatial measurement model, it is further proved that the fluctuation of regional housing price is not only affected by the income level, investment level, land restriction, population density and herd effect, etc., but also the spatial spillover effect of regional housing price fluctuation. This is reflected in the time lag when housing price changes in one area are transmitted to other areas, thus

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forming a spatial agglomeration of urban areas with relatively high or low housing prices.

In terms of real estate price control, it is necessary to strengthen the monitoring of cities, especially first-tier cities and new first-tier real estate markets. Keep abreast of the real-time market dynamics. When the real estate market is inflated with bubbles and housing prices are unreasonably high, take decisive measures to cool down and adjust the market.

In response to the above conclusions, this article draws the following conclusions: First of all, the spatial correlation of housing prices determines that the adjustment of housing prices in my country should be coordinated across the country. It has certain limitations simply from the changes in housing prices in individual large and medium cities.

In addition, on the basis of overall consideration of the country's housing price fluctuations, the policy must also be targeted. It is necessary to take into account the concept of levels of urban economic development, and formulate different control policies for cities at different levels of economic development. Provinces with similar development levels will ensure the sound development of the real estate market by promoting coordination and cooperation between regions to manage the real estate market.

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