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Spatial Correlation Test and Spillover Effect of Urban Housing Price in Shandong Province

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Abstract

Taking the housing prices of 17 cities in Shandong Province as the research object, this paper constructs a spatial panel model and uses spatial econometric tools to comprehensively test the spatial spillover effect of urban housing prices. The results show that: (1) there is a significant spatial correlation between urban housing prices in Shandong Province, and the spillover effect shows a positive change form of rising and falling at the same time. (2) The non spatial econometric models generally have errors in the estimation of the influencing factors of housing prices. (3) There is a significant spatial correlation between the influencing factors of urban housing prices in Shandong Province. Therefore, we should fully understand the spatial correlation of urban housing prices, and make targeted strategies to promote the realization of policy objectives.

Keywords

House price linkage; Correlation test; Spatial Durbin model; Spillover effect.

1. Introduction

In recent years, the problem of urban housing prices has been hotly debated by all walks of life. There are some problems, such as the high housing prices in the first tier cities, the excessive rise of housing prices in the second and third tier cities and so on. In this regard, the state vigorously advocates "housing without speculation", and the local governments have successively introduced policies such as restricting the purchase of land and adjusting the land supply for regulation. The housing price problem has been the focus of the government and academia for a long time. Most of the existing studies are based on the nationwide discussion and research, but the provincial regional population, information and other exchanges are closer, and the spatial correlation of house prices is stronger, so it is more representative and persuasive to study the spatial correlation of house prices at the provincial level.

As the carrier of Shandong Peninsula urban agglomeration, the urban real estate market in Shandong Province is closely related, which can better reflect the spatial correlation effect of urban housing price fluctuations. Considering the data integrity and availability, the data at district level is more complete and easy to obtain, which can better support the research.

Therefore, based on the existing research results, this paper uses the spatial panel model to study the spatial correlation degree of housing prices in 17 cities of Shandong Province, quantifies the spillover effect of housing prices more accurately, and obtains the corresponding policy enlightenment of housing price regulation.

2. Literature Review

On the spatial correlation and spillover effect of urban housing prices, scholars use different methods to study from multiple perspectives. In terms of spatial correlation of house prices, some scholars [1, 2] have confirmed the spatial correlation of house prices with the help of

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network analysis, social network analysis (SNA) and other methods. Other scholars use the unit root test of panel data [3], impulse response function [4], spatial econometrics [5] and other methods to test the spatial correlation of house prices, and find that house prices have a significant spatial diffusion pattern, and the price transmission mode is from coastal developed areas to inland underdeveloped areas [6].

In terms of house price spillover effect and influencing factors of house price fluctuation, John and Simon [7] used the maximum likelihood cointegration method to analyze the determinants of house prices in 11 regions of the UK, and tested the spillover effect of regional house prices. Clapp and Tirtiroglu [8] used the spatial econometric model to study the causes of house price fluctuation, and found that the market house price will be affected by the fluctuation of market house price in adjacent areas. Shih et al. [9] confirmed the spillover effect of urban housing prices in China through Johansen cointegration test and vector error correction model (VECM), and pointed out that there are spillover effects in Beijing, Shanghai and other regions, and the housing prices of provinces in potential infectious regions are integrated with each other. Montagnoli et al. [10] used a variety of advanced statistical methods, such as principal component analysis and panel unit root test, to analyze the convergence and spillover effects of house prices across the UK. According to the existing research, we can find that we have conducted a more in-depth study on the spatial spillover effect of house prices, and have achieved rich results.

However, it should be pointed out that the spatial econometric model considering the interaction of house prices among cities is rarely used. Some studies only consider the spatial correlation of house prices, and use the spatial autoregressive (SAR) model to analyze the linkage effect of house prices among regions, but do not consider the factors that affect the change of house prices. There may also be spatial interaction, so the estimation results may be biased. In view of this, on the basis of theoretical analysis, this paper takes the housing prices of 17 cities in Shandong Province as the research object, constructs a spatial econometric model, reveals the formation mechanism of spatial correlation of housing prices with the help of spatial Durbin model, and then analyzes its impact. The follow-up structure of this paper is as follows: the third part is the spatial correlation test of urban housing prices, to determine the spatial correlation of urban housing prices. The fourth part is the empirical analysis of the spatial correlation of urban house prices, which selects the model to analyze the linkage effect of house prices, and then makes an empirical analysis of the impact of the spatial correlation of urban house prices. The fifth part is to summarize the research conclusions and draw policy implications.

3. Spatial Correlation Test of Urban Housing Prices

3.1. Setting of Spatial Econometric Model

Lesage [11] pointed out that spatial Durbin model (SDM) is suitable for most spatial econometric analysis. In view of this, this paper chooses spatial Durbin model (SDM) to study the linkage effect of urban housing prices in Shandong Province, the model is set as follows:

$$Y_{it} = \lambda W Y_{it} + X_{it-1}\beta_1 + W X_{it-1}\beta_2 + \varepsilon_{it}$$
$$X_{it-1} = \left\{\ln PGDP_{it-1}, \ln POP_{it-1}, FD_{it-1}, \ln INCOME_{it-1}, INDS_{it-1}, \ln PCLS_{it-1}, UR_{it-1}\right\} \quad (1)$$

In equation (1), the explained variable Y represents the average price of housing; W is the spatial weight matrix; The explanatory variable X is the influencing factor of housing price. Considering the possible two-way causality between the explained variable (the average price of housing) and the explanatory variable (the influencing factors of housing price), the error

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occurs. At the same time, to avoid the possible lag effect of the influencing factors of housing price, the influencing factors are put into the model in the form of one lag period is the coefficient to be estimated; λ, β_1, β_2 is the coefficient to be estimated [12]; ε is the residual; it is city and time respectively. According to the research of Elhorst [13], this paper introduces the spherical distance data of 17 cities in Shandong Province, and constructs the inverse distance matrix as the spatial weight matrix.

3.2. Data Sources

3.2.1. Explain Variable Data

Based on the existing research, this paper sets the influencing factors of house price fluctuation as follows:

(1) Economic development level (PGDP). The high level of economic development of the city, its residents have a higher level of income, strong purchasing power of residents make their own house prices change under the promotion of higher demand. In addition, the higher the level of economic development of a city, the greater the impact on the surrounding cities. On the one hand, the higher the economic development level of a city, the more attractive it is to the population elements, which promotes the population of surrounding cities to gather in the city, affects the population of surrounding cities, and then affects the economic development level of the city; On the other hand, cities with high level of economic development will gradually produce "crowding effect" with the continuous development. Higher production costs make enterprises turn to the cities with lower land prices and stronger policy support, resulting in changes in the economic development level of themselves and the surrounding cities. In this role, it has an impact on the housing prices of its related cities.

(2) Population size (POP). Demand is an important factor affecting the fluctuation of house prices. The increase of population means more housing demand, which leads to the rise of house prices. In addition, because of the differences in the level of economic development between the city and the living standard of the residents, the population often shifts from the city with low economic development or low income to the areas with high economic development or high income level, which makes the population flow into the city, and the housing demand increases, and the population outflow into the city and housing demand decreases. Then it has an impact on population inflow and outflow of city housing prices.

(3) Degree of financial development (FD). The level of urban financial development may lead to the spatial Arbitrage Behavior of the real estate demander, which leads to the increase of housing demand and the rise of housing price. In addition, generally speaking, cities with higher level of financial development tend to be in the leading or leading position in the market, which is bound to have an impact on the financial development of other related cities, thus affecting the housing prices of other cities.

(4) Income level (INCOME). Higher income level of residents will produce higher housing purchase demand, which will promote their own housing prices. In addition, first of all, for enterprises, a higher income level means higher production costs, and it also means that cities have greater purchasing power. Under the action of centrifugal force and centripetal force generated by higher income level and purchasing power, enterprises will migrate between cities, resulting in the flow of population and capital between cities, It leads to the change of urban housing price. Secondly, compared with enterprises, the centripetal force of cities with high residents' income level is greater than the centrifugal force, which can produce enough attraction to the population. The migration of population between cities has an impact on the housing demand of the population flowing out of cities, resulting in the change of housing prices.

(5) Industrial structure (INDS). The proportion of the tertiary industry is used as the index to measure the industrial structure. The proportion of the tertiary industry is a symbol of the level

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of urban development. Generally speaking, cities with higher proportion of the tertiary industry have more modern industrial development and higher level of economic development, which have greater attraction. Therefore, it has a higher housing demand, which has an impact on their own housing prices. In addition, due to the mobility of population and the lack of location characteristics of industrial enterprises and the initiative of choosing investment places according to preferential policies, the industrial structure between cities will change reasonably under the influence of market and system, which will lead to the change of housing demand in cities, and then affect their housing prices.

(6) Per capita residential land area (PCLS). The larger the per capita residential land area is, the higher the living level of the city is, reflecting the possibility that the city's house purchase policy is loose or the land cost is low, resulting in the housing price at a low level relative to its own income level and the living pressure of other cities. On the one hand, this situation will affect the housing prices of related cities by attracting the flow of factors; on the other hand, it will make related cities promote the development of their own real estate market by reducing the land supply price and improving the house purchase policy under the promotion of " yardstick competition", leading to changes in their housing prices.

(7) Urbanization rate (UR). The higher urbanization rate means that the city has a larger housing demand, which has an impact on its own housing prices. In addition, due to the potential inter governmental competition mechanism and the existence of assessment indicators, local governments in associated cities may increase policy efforts, speed up the process of urbanization and improve the urbanization rate, which will lead to the change of their own housing prices.

3.2.2. Average Price Data of Urban Housing

Due to the merger of Lai Wu into Jinan in 2019, it is difficult to obtain independent data. Considering the integrity of the data, the time range of data collection is from 2007 to 2018. The data mainly come from Shandong Statistical Yearbook, China Regional Economic Statistical Yearbook and China Real Estate Statistical Yearbook.

3.2.3. Spatial Weight Matrix Data

Table 1. Descriptive statistics of relevant variables

Variable	Mean	Std.Dev.	Min	Max	Index construction process and data sources
Average house price	0.426	0.181	0.147	1.237	Sales area / sales price , Data sources are shown in the text , Take natural logarithm
PGDP	1.624	0.549	- 0.165	2.955	Per capita GDP, The data is from Shandong Statistical Yearbook, Take natural logarithm
POP	6.198	0.584	4.831	7.073	The data is from Shandong Statistical Yearbook, Take natural logarithm
FD	0.774	0.282	0.437	1.871	Total deposits and loans at the end of the year / Total GDP, The data is from China Urban Statistical Yearbook
INCOME	1.414	0.410	0.362	2.215	Average wage of on-the-job workers , The data is from China Urban Statistical Yearbook, Take natural logarithm
INDS	0.386	0.078	0.201	0.605	Total amount of tertiary industry / Total GDP, The data is from Shandong Statistical Yearbook
PCLS	2.148	0.669	0.207	3.383	Residential land area / population size , The data is from China Urban Statistical Yearbook , Take natural logarithm
UR	0.493	0.140	0.194	0.737	Registered residence population in cities and towns / total population , The data is from Shandong Statistical Yearbook

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Through the administrative division map of Shandong Province, the longitude and latitude data of 17 cities in Shandong Province are obtained, and the standard spatial weight matrix is constructed by using matlab program toolkit. The construction process, data sources and descriptive statistical results of each variable are shown in Table 1.

3.3. Results of Spatial Econometric Analysis

According to the research of Anselin [14], Elhorst [15], and so on, lessons were drawn from the research paradigm established by them, according to the spatial correlation test, the spatial model setting test, the fixed and random effect test, and the parameter estimation sequence.

(1) LM and robust LM Test. The original hypothesis is that the model is non spatial panel model, and the alternative hypothesis is SAR or SEM model. The results are shown in Table 2.

Table 2. Results of model spatial correlation test

Test statistics	Statistics	P
Spatial error:		
Lagrange multiplier	42.495	0.000
Robust Lagrange multiplier	44.080	0.000
Spatial lag:		
Lagrange multiplier	10.748	0.001
Robust Lagrange multiplier	12.333	0.000

According to table 2, we can see that the statistics reject the original hypothesis, so we should build a spatial panel model and support both SAR and SEM models [16-18]. Therefore, equation (1) should build a SDM model to further test whether the SDM model can be simplified into SAR model or SEM model.

(2) Wald test and LR test. Two original hypotheses are put forward, H1: $\beta_2 = 0$; H2: $\beta_2 + \lambda\beta_1 = 0$,If H1 and H2 are rejected, SDM model is selected; If you accept the original hypothesis H1: $\beta_2 = 0$,SAR model should be established; If you accept the original hypothesis H2: $\beta_2 + \lambda\beta_1 = 0$, the SEM model was established. The results of setting and selecting spatial model are shown in Table 3.

Table 3. Test results of model form setting

Test statistics	Statistics	P
Wald test (SAR)	28.31	0.000
LR test (SAR)	26.42	0.000
Wald test (SEM)	28.27	0.000
LR test (SEM)	26.08	0.001

Note: ① Wald test (SAR), LR test (SAR), Wald test (SEM) and LR test (SEM) are Wald and LR test statistics of SAR and SEM models respectively.

According to table 3, the statistics are significant at the 1% level, that is, the two hypotheses H1 and H2 are rejected, which indicates that the SDM model should be constructed.

(3) Fixed effect test and random effect test. According to the research of Elhorst [15], the fixed effect and random effect were selected by Hausman test. Then we test the regional fixed effect, the time fixed effect and the time and space double fixed effect. The results are shown in Table 4.

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Table 4. Results of Hausman test and effect test

Test statistics	Statistics	P
Hausman test	-11.34	/
Ind	46.30	0.000
Time	153.60	0.000

Note: ① Ind and Time are regional fixed effect and time fixed effect respectively. ② The '/' in the table indicates that the item does not enter the relevant model.

According to the research of Schreiber [19], if Hausman's test value is negative, it indicates that the asymptotic hypothesis of the basic hypothesis of re model can not be satisfied, that is, fixed effect is selected. In Table 4, the Hausman test value was -11.34, so the fixed effect model was selected. From table 4, it can be found that both the regional fixed effect and the time fixed effect statistics reject the original hypothesis at the significance level of 1%, indicating that the spatial and time double fixed model should be chosen. According to the results of Hausman test and effect test, a double fixed spatial and temporal Durbin model was constructed.

(4) Parameter estimation. Based on the research of Elhorst [20], this paper uses the maximum likelihood method to estimate the parameters, and the results are shown in Table 5.

Table 5. Model estimation results

Variable	Coef.	P
W*Pit	0.584	0.000
lnPGDPit-1	0.190	0.000
lnPOPit-1	0.068	0.092
FDit-1	0.226	0.000
lnINCOMEit-1	- 0.104	0.108
INDSit-1	0.271	0.354
lnPCLSit-1	0.037	0.033
URit-1	- 0.381	0.000
W*lnPGDPit-1	- 0.148	0.466
W*POPit-1	- 0.128	0.568
W*FDit-1	- 0.024	0.846
W*lnINCOMEit-1	0.283	0.275
W*INDSit-1	0.256	0.795
W*lnPCLSit-1	- 0.247	0.015
W*URit-1	0.110	0.514
σ2	0.002	/
R2	0.827	/

Note: ① W * Pit is the spatial lag term of the explained variable (average price of housing). ② W * lnPGDPit-1, W * lnPOP it-1, W * FD it-1, W * lnINCOMEit-1, W* lnINDSit-1, W * lnPCLSit-1 and W * UR it-1 were the spatial lag terms of the explanatory variables. ③ "/" in the table indicates that the item does not enter the related model.

By analyzing the results of parameter estimation of spatial panel model in Table 5, two conclusions can be drawn.

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(1) There is a significant spatial correlation between urban housing prices. It can be seen from table 5 that the coefficient of the spatial correlation term of urban housing price, that is, the spatial lag term of the explained variable ($W * P_{it}$), has passed the Z test at the significance level of 1%, which indicates that there is a significant interaction between urban housing prices in Shandong Province, which is a typical mechanism for the formation of spatial correlation of housing prices. A city's house price is not only constrained by the city's own situation, but also affected by the house price of other related cities.

(2) The spatial correlation of urban housing price shows positive spatial spillover effect. In Table 5, the coefficient of the spatial lag term of the explained variable (Average housing price) is positive, which indicates that the spillover effect of housing prices in cities with spatial correlation in Shandong Province is in the form of positive change with the same rise and fall.

4. An Empirical Analysis of the Spatial Correlation of Urban Housing Prices

4.1. The Establishment of Spatial Correlation Analysis Model of Urban Housing Price

According to the research of Behrens and Thisse [21], due to the existence of spatial spillover effect, the influencing factors of urban housing price will potentially affect the related urban housing price. Therefore, the impact of changes in influencing factors of urban housing price on the urban housing price and other related urban housing prices can not be described by traditional econometric models, but should be analyzed and studied by spatial econometric models. Specific to this paper, there are two influencing paths for the spatial Durbin model : One is the change of a certain influencing factor of i city housing price, which causes the change of the city's housing price. The existence of spatial correlation of city housing price indirectly leads to the change of other related cities' housing price; Second, the influencing factors of i city's housing price change. Due to the existence of spatial correlation of explanatory variables (influencing factors of housing price), the influencing factors of housing prices in other related cities change, and then indirectly affect the changes of housing prices in other related cities.

According to the research of Lesage and Pace [22], spatial correlation can be measured by spatial weight matrix analysis. In equation (1) model, the adjustment of urban i house price can be expressed by the following process.

$$\begin{cases} Y = \lambda WY + X\beta_1 + WX\beta_2 + \varepsilon \\ \left(I_n - \lambda W\right)Y = X\beta_1 + WX\beta_2 \\ Y = \sum S_r\left(W\right)X_r + V\left(W\right)\varepsilon \end{cases} \tag{2}$$

In formula (2), the interpreted variable (Y), explanatory variable (X), space weight matrix (W) are the same as those of formula (1); $S_r\left(W\right) = V\left(W\right)\left(I_n\beta_1^r + W\beta_2^r\right)$; $V\left(W\right) = \left(I_n - \lambda W\right)^{-1} = I_n + \lambda W + \lambda^2 W^2 + \lambda^3 W^3 + \ldots$; I_n is a $n*n$ identity matrix; others are coefficients. The above formula is expressed in the form of matrix, as shown in equation (3).

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$$\begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{bmatrix} = \sum_{r=1}^{k} \begin{bmatrix} S_r(W)_{11} & S_r(W)_{12} & \cdots & S_r(W)_{1n} \\ S_r(W)_{21} & S_r(W)_{22} & \cdots & S_r(W)_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ S_r(W)_{n1} & S_r(W)_{n2} & \cdots & S_r(W)_{nn} \end{bmatrix} \begin{bmatrix} X_{1r} \\ X_{2r} \\ \vdots \\ X_{nr} \end{bmatrix} + V(W)\varepsilon \tag{3}$$

In this case, the impact of the change of i ($i = 1, 2, \ldots, n$) and r ($r = 1, 2, \ldots, k$) on the housing prices of cities in Shandong Province can not be expressed by ols regression coefficient, but should be expressed by the partial derivative: $\frac{\partial y_i}{\partial x_{ir}} = S_r(W)_{ii}$. This formula measures the change of the r factor of city i, which leads to the fluctuation of the housing price in the city, including the local influence in the city and the feedback effect caused by the change of the housing price in the associated city, which is called "Direct effect"[23]. In addition, the influence of the change of the r ($r = 1, 2, \ldots, k$) factor (x_{jr}) of city j ($j = 1, 2, \ldots, n$) on the housing price of city i is not equal to 0, and its influence is expressed by the partial derivative: $\frac{\partial y_i}{\partial x_{jr}} = S_r(W)_{ij}$. It is called "Indirect effect" or "Spatial spillover effect", that is, the spatial spillover effect produced by the r factor of city j (the influence of this factor on the fluctuation of house prices in other related cities).

4.2. Empirical Analysis on the Spatial Correlation of Urban Housing Prices

Through the spatial correlation test of urban housing prices, this paper can see that the change of urban housing prices in Shandong Province has a typical spatial correlation mechanism, and estimate the direct and indirect effects of the influencing factors of housing prices. By analyzing the parameter estimation results of direct effect, indirect effect and total effect of spatial Durbin model in Table 6, the following conclusions are drawn.

(1) The results show that the direct effects of economic development level (lnPGDP), population size (lnPOP), financial development level (FD), per capita residential land area (lnPCLS) and urbanization rate (UR) pass the Z test at the significance level of 1% and 5%. Because the direct effect represents the marginal influence of economic development level, population, financial development degree, per capita residential land area and urbanization rate on the average price of housing in the spatial panel model, by comparing the coefficient of relevant variables of the direct effect and the non spatial panel model, It can be found that there is a certain deviation between the coefficient of non spatial panel model and the coefficient of direct effect related variable, that is, there is a certain degree of underestimation or overestimation. Specifically, the direct effects of economic development level, population, financial development degree, per capita residential land area and urbanization rate in the spatial panel model are estimated to be 0.177, 0.074, 0.226, 0.047 and -0.358, respectively, which means that the impact of economic development level (0.133) is underestimated by 24.86% and the impact of population (0.05) is underestimated by 32.43%, The impact of financial development degree (0.143) is underestimated by 36.73%, the impact of per capita residential land area (0.023) is underestimated by 51.06%, and the impact of urbanization rate (- 0.137) is underestimated by 61.73%. However, most studies usually use non spatial econometric models to analyze the influencing factors. Through comparison, it is found that there is a significant deviation in the parameter estimation of the influence of variables without considering the spatial correlation.

(2) The indirect effects of economic development level, population size, financial development degree, per capita residential land area and urbanization rate respectively pass the Z test at the significance level of 5%, 10% and 1%, and the estimated values are 0.300, 0.126, 0.384, 0.080 and-0.601, respectively, indicating that the above variables have significant spatial spillover effects. Among them, the estimated value of indirect effect of economic development level,

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population, financial development degree and per capita residential land area is positive, which indicates that the change of economic development level, population, financial development degree and per capita residential land area of a city has a positive change trend on the local impact of the city and the impact of related cities. This means that the growth of economic development level, population, financial development degree and per capita residential land area of a city in Shandong Province will not only lead to the rise of housing prices in the city, but also lead to the rise of housing prices in related cities. The estimated value of the indirect effect of urbanization rate is negative, which means that the change of urbanization rate of a city's local impact on the city and the spatial correlation impact on the related cities show a reverse trend. This shows that the increase of urbanization rate of a city in Shandong Province will not only lead to the decline of housing prices in the city, but also lead to the decline of housing prices in related cities.

(3) By measuring the ratio of the absolute value of the direct and indirect effects of the influencing factors, we can get the proportion of rising and falling. Among them, the absolute value ratio of direct effect and indirect effect of economic development level, population, financial development degree and per capita residential land area is 0.177:0.300, 0.074:0.126, 0.226:0.384 and 0.047:0.080 respectively, that is, the rising ratio is 1:1.69, 1:1.70, 1:1.70 and 1:1.70 respectively. The absolute value ratio of direct and indirect effects of urbanization rate is 0.358:0.601, that is, the decline ratio is 1:1.68. However, the traditional non spatial econometric model thinks that the influencing factors are independent. In other words, the non spatial econometric model does not have the indirect effect considered in the spatial panel model, which does not really reflect the impact of economic development level, financial development level, per capita residential land area and urbanization rate on the spatial spillover effect of housing prices in related cities.

Table 6. Estimation results of direct and indirect effects of spatial panel model

Variable	(Explained variable: Average house price)			
	Direct effect	Non spatial panel form estimation results	Indirect effect	Total effect
lnPGDPit-1	0.177***	0.133***	0.300**	0.477***
lnPOPit-1	0.074**	0.05***	0.126*	0.201**
FDit-1	0.226***	0.143***	0.384**	0.610***
lnINCOMEit-1	- 0.041	0.108***	- 0.081	- 0.122
INDSit-1	0.352	0.727***	0.571	0.923
lnPCLSit-1	0.047***	0.023	0.080*	0.126**
URit-1	- 0.358***	- 0.137	- 0.601***	- 0.959***

Note: ① *, **, and * * * are significant at 10%, 5% and 1% levels, respectively.

5. Research Conclusion and Enlightenment

This paper takes the housing prices of 17 cities in Shandong Province as the research object, constructs a spatial panel model, takes the average housing price as the explained variable, comprehensively tests the spatial spillover effect of housing price changes in 17 cities in Shandong Province, and uses spatial measurement tools to analyze the impact of spatial correlation of urban housing prices. The results show that:

(1) There is a significant spatial correlation of urban housing prices in Shandong Province, which has a typical formation mechanism of spatial correlation. The spillover effect of urban housing prices with spatial correlation is in the form of positive change with rising and falling.

(2) In the ordinary non spatial econometric model, the estimation of the influencing factors of house price fluctuation does not consider the spatial correlation, which leads to some errors in

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the estimation results. For urban housing prices in Shandong Province, the impact of economic development level, population, financial development, per capita residential land area and urbanization rate is underestimated by 24.86%, 32.43%, 36.73%, 51.06% and 61.73% respectively.

(3) There is a significant spatial correlation among the influencing factors of urban housing price changes in Shandong Province. For housing prices, the influencing factors with spatial spillover effect are the level of economic development, population, degree of financial development, per capita residential land area and urbanization rate, that is, these factors will not only affect the fluctuations of local housing prices, but also affect the fluctuations of housing prices in other related cities through spatial spillover effect.

Based on the above conclusions, we can draw policy implications:

(1) Fully realize the spatial correlation of urban housing prices, and provide new ideas for the government to control urban housing prices. We can control the house price of a city and make rational use of the spillover effect of the same rise and fall of the house price of a city, so as to further better control the house price of other related cities. However, the city government should also pay more attention to the cities with spatial correlation of housing prices, so as to avoid the phenomenon that one city drives the abnormal fluctuation of housing prices in other related cities, and then make the coordinated development of urban real estate market.

(2) Fully realize the spatial correlation of the influencing factors of urban housing prices. By improving the urbanization rate of cities and exerting the negative spatial spillover effect of urbanization rate, the purpose of reducing the price of urban housing in Shandong Province can be achieved; By improving the level of economic development and financial development of the city, increasing the number of population and expanding the per capita residential land area, the positive spatial spillover effect of influencing factors can be exerted to achieve the purpose of improving the urban housing price. We should make rational use of the influence of influencing factors on related cities, and then formulate more targeted strategies and measures to promote the realization of relevant goals and the steady and healthy development of the real estate market.

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